OCTOBER 1957

Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 49 • NO. 10

No water fall at Kansas City as tank stands up to 500-mph tornado

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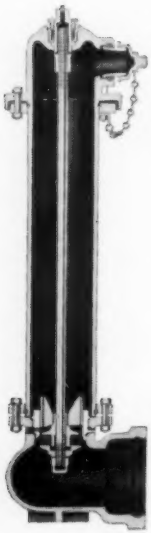
FOR A LONG-LASTING LOW-COST INSTALLATION



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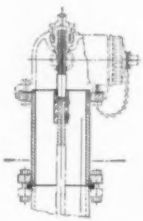

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October 1957

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Journal AWWA is published monthly at Prince & Lemon Sts., Lancaster, Pa., by the Am. Water Works Assn., Inc., 2 Park Ave., New York 16, N.Y., and entered as second class matter Jan. 23, 1943, at the Post Office at Lancaster, Pa., under the act of Aug. 24, 1912. Accepted for mailing at a special rate of postage provided for in paragraph (d-2), Section 34.40, P. L. & R. of 1948. Authorized Aug. 6, 1918. $7.00 of members' dues are applied as a subscription to the JOURNAL; additional single copies to members—60 cents; single copies to non-members—85 cents. Indexed annually in December; and regularly by *Industrial Arts Index* and *Engineering Index*. Microfilm edition (for JOURNAL subscribers only) by University Microfilms, Ann Arbor, Mich.

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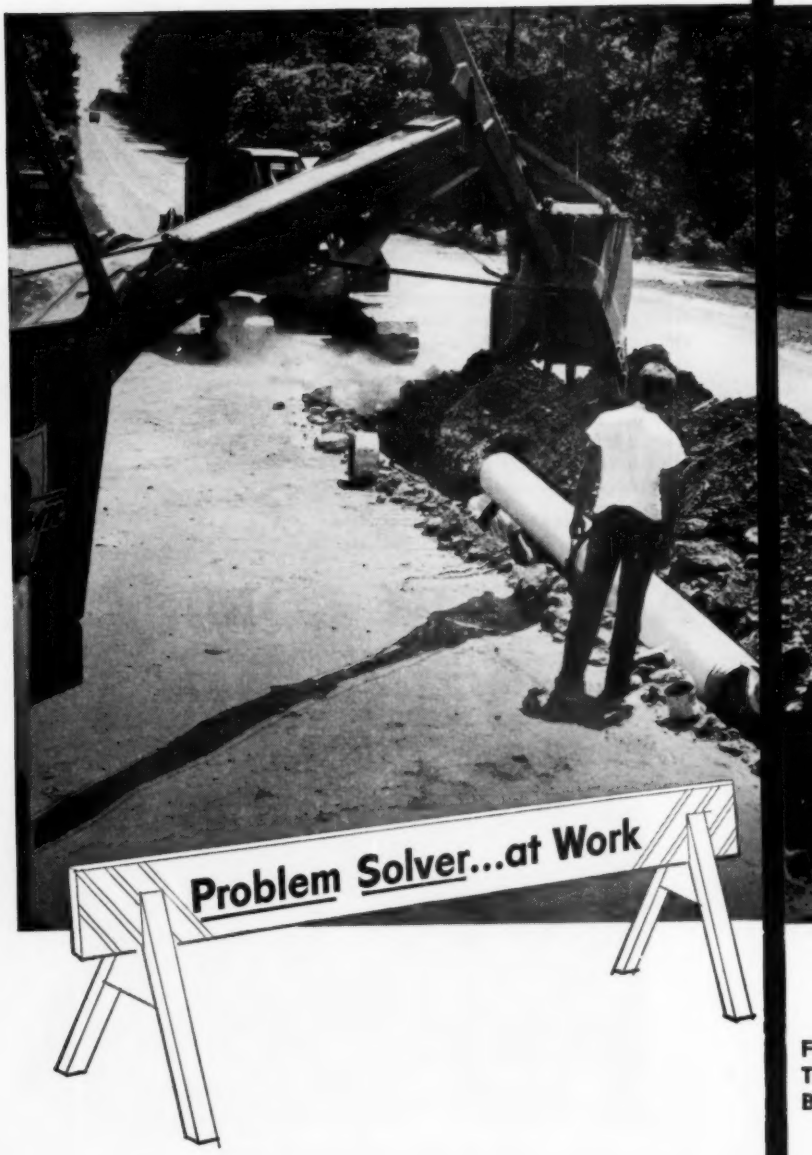

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Coming Meetings

AWWA SECTIONS

Fall 1957 Meetings

Oct. 13–16—Southwest Section, at Skirvin Hotel, Oklahoma City, Okla. Secretary, Leslie A. Jackson, Mgr.-Engr., Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

Oct. 16–18—Iowa Section, at Fort Des Moines Hotel, Des Moines. Secretary, J. J. Hail, Supt., Water Dept., City Hall, Dubuque.

Oct. 17–18—Canadian Section, Maritime Branch, at Nova Scotian Hotel, Halifax, N.S. Secretary, J. D. Kline, Asst. Mgr. & Chief Engr., Public Service Com., 162 Lady Hammond Rd., Halifax, N.S.

Oct. 20–23—Alabama-Mississippi Section, at Buena Vista Hotel, Biloxi, Miss. Secretary, C. M. Mathews, Public Service Com., 119 W. Commercial St., Yazoo City, Miss.

Oct. 23–24—West Virginia Section, at McClure Hotel, Wheeling. Secretary, H. W. Hetzer, Engr., West Virginia Water Service Co., Box 1906, Charleston 27.

Oct. 24–26—New Jersey Section, at Hotel Madison, Atlantic City. Secretary, A. F. Pleibel, Dist. Sales Manager, R. D. Wood Co., 683 Prospect St., Maplewood.

Oct. 29–Nov. 1—California Section, at Hotel St. Claire, San Jose. Secretary, Henry J. Ongerth, Sr. San. Engr., Bureau of San. Eng., 2151 Berkeley Way, Berkeley.

Oct. 30–Nov. 1—Chesapeake Section, at Sheraton-Park Hotel, Washington, D.C. Secretary, C. J. Lauter, 6955—33rd St., N.W., Washington, D.C.

Nov. 6–8—Virginia Section, at Hotel Roanoke, Roanoke. Secretary, J. P. Kavanagh, Dist. Mgr., Wallace & Tiernan Inc., 213 Carlton Terrace Bldg., Roanoke.

Nov. 10–13—Florida Section, at Roosevelt Hotel, Jacksonville. Secretary, J. D. Roth, P.O. Bin "O," Miami Beach 39.

(*Continued on page 10*)

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Coming Meetings

(Continued from page 8)

Nov. 11–13—North Carolina Section, at Hotel Sir Walter, Raleigh. Secretary, W. E. Long Jr., State Stream Sanitation Com., Raleigh.

Spring 1958 Meetings

Feb. 5–7—Indiana Section, at Sheraton-Lincoln Hotel, Indianapolis. Secretary, C. H. Canham, 3517 Manor Court, Indianapolis.

Mar. 12–14—Kansas Section, at Lamer Hotel, Salina. Secretary, Harry W. Badley, Representative, Neptune Meter Co., 119 W. Cloud, Salina.

Mar. 20–22—Montana Section, at Florence Hotel, Missoula. Secretary, Arthur W. Clarkson, Asst. Director, Div. of Environmental Sanitation, State Board of Health, Helena.

Mar. 23–25—Southeastern Section, at Dinkler-Plaza Hotel, Atlanta, Ga. Secretary, N. M. deJarnette, Engr., Div. of Water Pollution Control, State Dept. of Health, 309 State Office Bldg., Atlanta, Ga.

Mar. 26–28—New York Section, at Van Curler Hotel, Schenectady. Secretary, Kimball Blanchard, Ludlow Valve Mfg. Co., Inc., 11 W. 42nd St., New York 36.

Mar. 26–28—Illinois Section, at LaSalle Hotel, Chicago. Secretary, Dewey W. Johnson, Research Engr., Cast Iron Pipe Research Assn., 3440 Prudential Plaza, Chicago.

Apr. 16–18—Nebraska Section, at Cornhusker Hotel, Lincoln. Secretary, John E. Olsson, Cons. Engr., 408 Sharp Bldg., Lincoln.

May 15–17—Pacific Northwest Section, at Davenport Hotel, Spokane, Wash. Secretary, Fred D. Jones, Asst. Supt., Water Dept., 306 City Hall, Spokane, Wash.

May 15–17—Arizona Section, at El Conquistador Hotel, Tucson. Secretary, Stanford I. Roth, Supervisor of Water Collections, Div. of Water & Sewers, Phoenix.

Jun. 1–4—Canadian Section, at Royal York Hotel, Toronto, Ont. Secretary, A. E. Berry, Gen. Mgr. & Chief Engr., Ontario Water Resources Commission, Parliament Buildings, Toronto.

Jun. 25–27—Pennsylvania Section, at Hotel Lawrence, Erie. Secretary, L. S. Morgan, Div. Engr., State Dept. of Health, Greensburg.

OTHER ORGANIZATIONS

Oct. 24–25—Engineers General Assembly, joint conference of Engineers Joint Council and Engineers Council for Professional Development, at Statler Hotel, New York, N.Y.

Nov. 2–8—World Metallurgical Congress, sponsored by American Society for Metals, at Chicago, Ill.

Nov. 11–15—Annual Meeting, American Public Health Assn., Cleveland, Ohio.

Nov. 13–15—National Conference on Standards, American Standards Assn., at St. Francis Hotel, San Francisco, Calif.

Dec. 2–6—Exposition of Chemical Industries, at the Coliseum, New York, N.Y.

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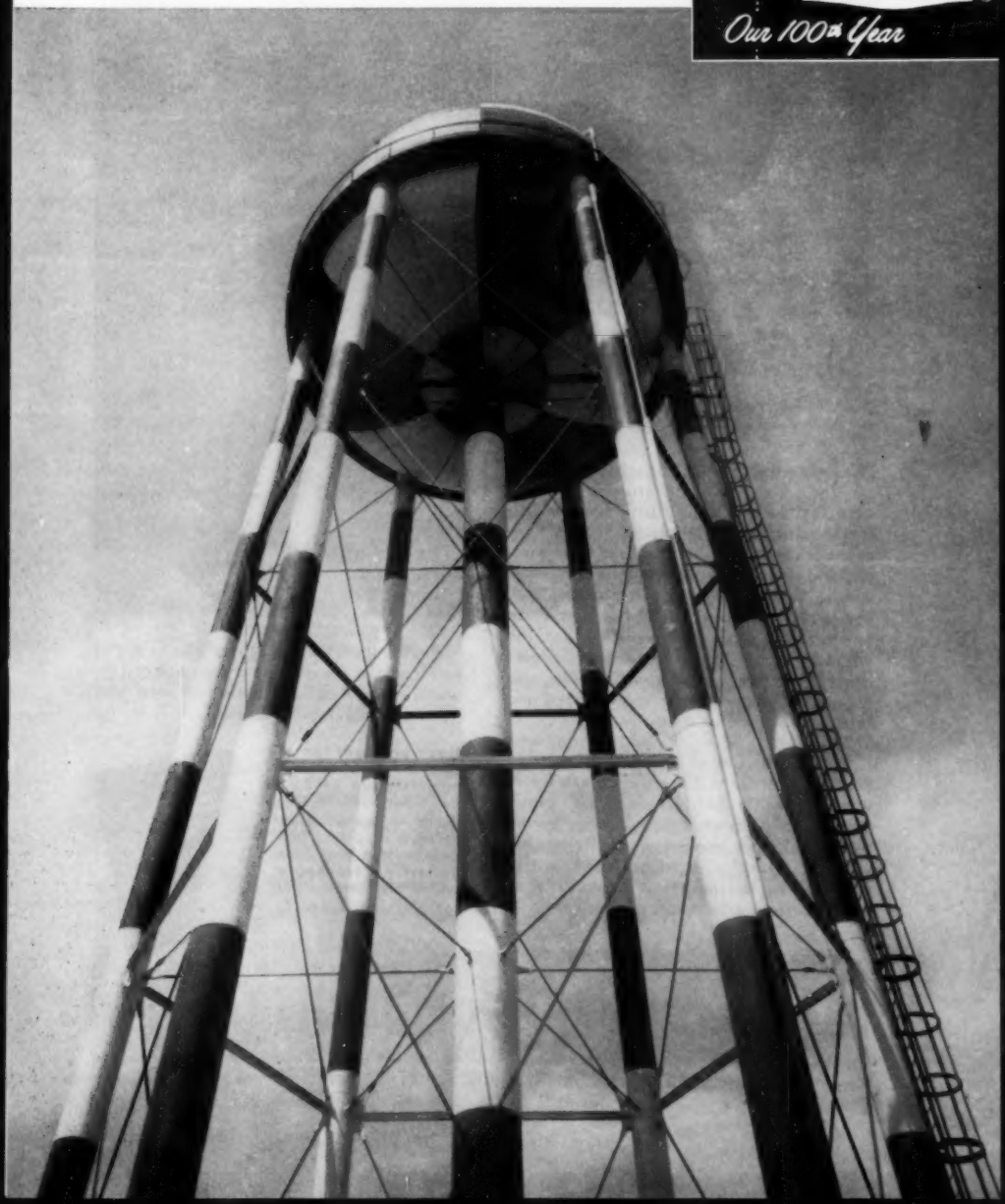

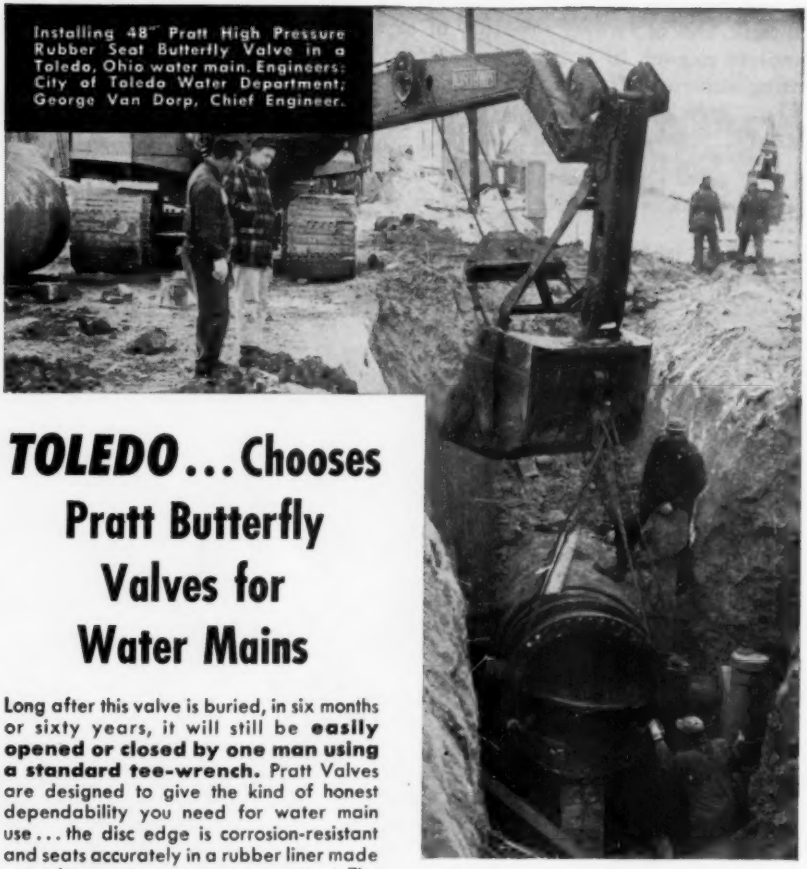

Installing 48" Pratt High Pressure Rubber Seat Butterfly Valve in a Toledo, Ohio water main. Engineers: City of Toledo Water Department; George Van Dorp, Chief Engineer.

TOLEDO... Chooses Pratt Butterfly Valves for Water Mains

Long after this valve is buried, in six months or sixty years, it will still be **easily opened or closed by one man using a standard tee-wrench.** Pratt Valves are designed to give the kind of honest dependability you need for water main use... the disc edge is corrosion-resistant and seats accurately in a rubber liner made extra-heavy to prevent permanent set. The one-piece stainless steel valve shaft rotates in lifetime lubricated bronze bearings, and the operator is permanently lubricated and sealed to withstand seepage.

In 1956, the City of Toledo purchased 13 Pratt Rubber Seat Butterfly Valves for its water mains, in 24", 30", and 48" diameters. All of them were designed for buried service without protective vaults around valve or operator, **adding substantial savings in installation costs** to their freedom from maintenance problems.

Pratt engineers stand ready to help you select valves for distribution service or any water works application. Call on them with your next valving problem.

Have you sent for your copy? . . . of Pratt's 40 page Manual of Rubber Seat Butterfly Valves. Useful — contains latest pressure drop and flow data, conversion tables, butterfly valve theory and application.
Catalog B-2A.

HENRY PRATT — RUBBER SEAT Butterfly Valves

Henry Pratt Company, 2222 S. Halsted St., Chicago 8, Ill. Representatives in principal cities

ALOXITE® Underdrains solve filter problems for growing Barranquilla

Water consumption in Barranquilla, Colombia, jumped from 8.04 to 19.10 MGD between 1935 and 1950. This created quite a problem for the city's Empress Publicas Municipales. They tackled it by giving experts a free hand to investigate every method and material known in order to give Barranquilla the best water supply system obtainable.

Today Barranquilla boasts a brand new 12-MGD water filtration plant. And each of its three 4-MGD filter units is equipped with ALOXITE® aluminum oxide porous plate underdrains. ALOXITE underdrains were chosen because they have proved they can handle growing loads like those at Barranquilla with freedom from mudballs and with minimum loss of head. Complete backwashing is accomplished without upset beds.

All work on this outstanding installation was under the supervision of Dr. Samuel L. Hollopeter and Dr. Efraim Pereira, Director General and Chief Engineer, respectively, of the Empress Publicas Municipales.

Answer your questions about porous media with Carborundum's 56 page booklet, "Porous Media." It's yours for the asking. Just write to:

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Mean Job? Tough Requirements?

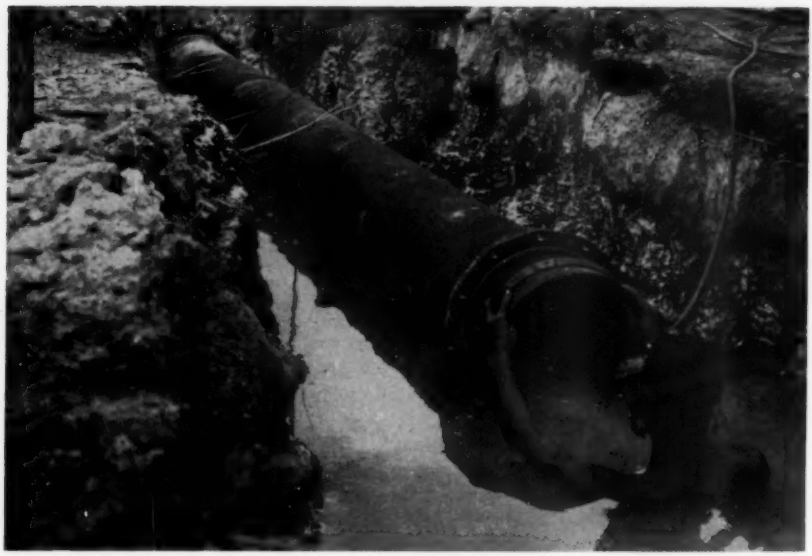
AMERICAN

CAST IRON PIPE

Happily, not all pipe must be installed under conditions as difficult as this Florida job. But when conditions — both for installation *and* service — are severe, American Cast Iron pipe is your wisest choice.

Supplied with the easy-to-assemble joint that best fits your requirements, American Cast Iron pipe goes down fast — to stay. The outstanding service of cast iron pipe for a century or more, under a wide variety of conditions, is a matter of record.

If installation or service conditions are getting you into deep water, call in your American Cast Iron Pipe Company representative. He can help you out.



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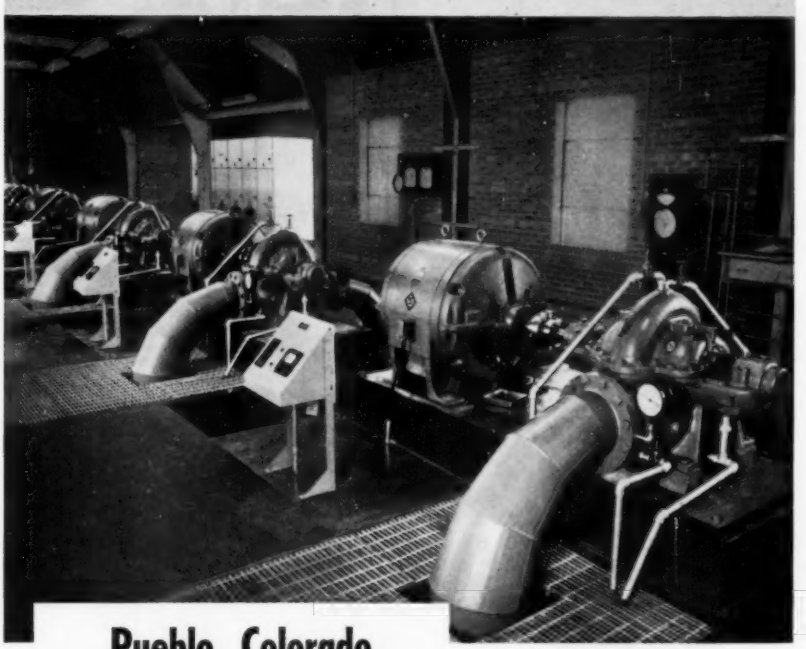
AMERICAN CAST IRON PIPE CO.
BIRMINGHAM 2, ALABAMA

Allis-Chalmers **PUMPS** solve a water works problem



Pueblo, Colorado again purchases Allis-Chalmers Equipment for increased water capacity

Public Water Works No. 2, Pueblo, Colorado . . . two 12 by 10 SHS pumps, 3500 gpm, 290-ft head, driven by 350-hp, 1770-rpm Allis-Chalmers motors — and three 12 by 10 SH pumps, 6000 gpm, 290-ft head, with 600-hp, 1770-rpm Allis-Chalmers motors.

This progressive industrial city of over 100,000 expects to double its population in less than 30 years. This growth pattern called for immediate increased capacity and plans for future expansion. Because Allis-Chalmers pumps have been giving long, dependable service with minimum maintenance, Pueblo specified Allis-Chalmers again.

Why you get MORE pump value when you specify Allis-Chalmers

You draw on Allis-Chalmers wide experience in supplying pumps for public works . . . for expert engineering and application help. You get pumps made of best-quality materials, of heavy duty construction, of high-efficiency design. Allis-Chalmers is the only company that offers you "one source" responsibility, with a complete unit — pump, motor and control — all built to work together — all built by Allis-Chalmers.

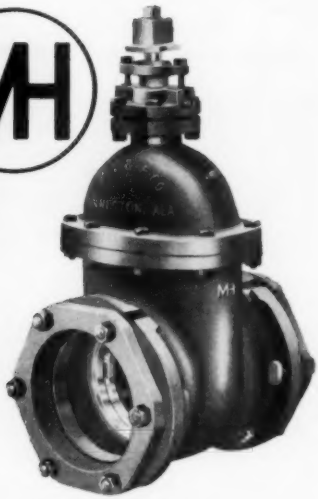
For MORE information, call your local A-C office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

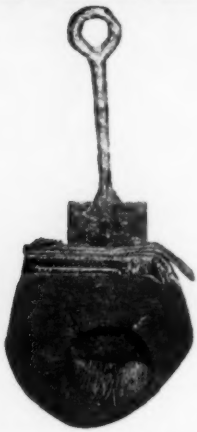
A-C ALLIS-CHALMERS

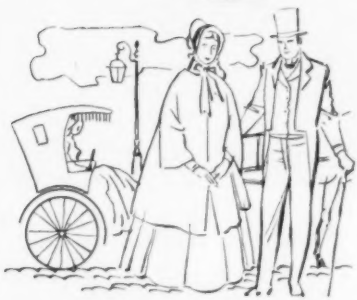
ALLIS-CHALMERS

A-5295

WATER CONVEYANCE ...is a modern art







Water always has been vitally important to Man. Ancient camps and cities always were located near water. Yet, conveyance of large quantities of water by pipe lines, pumps and valves for domestic consumption, industrial supply and fire protection, is comparatively a modern art. Only 100 years ago in this country, crude pipes and valves made of bored logs were in common use.

Compare the wooden valve body with its crude iron-paddle gate used in Mobile, Alabama, 1840-1850, with the modern M&H mechanical joint valve above. M & H valves and hydrants today are engineered products, made to conform to exacting standard specifications. That's why leading water works engineers today use M & H valves and hydrants.

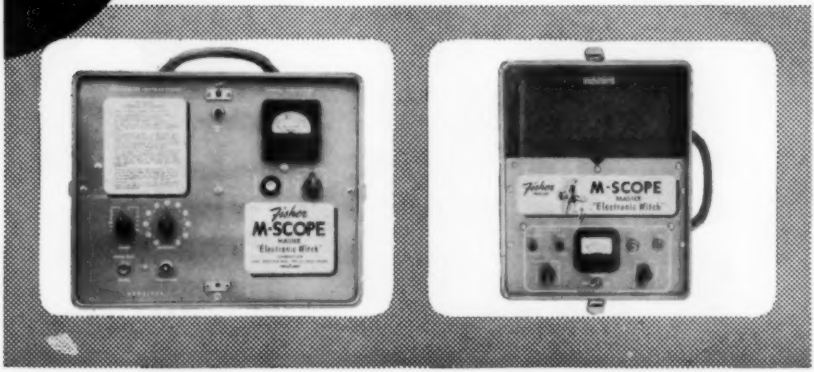
For complete information, address

M&H VALVE AND FITTINGS COMPANY
ANNISTON, ALABAMA

SUBSIDIARY OF W WALWORTH

New!

TIME-$AVING COMBINATION LEAK DETECTOR-PIPE LOCATOR



THE M-SCOPE MASTER
Electronic Witch Combination

You're looking at the much-talked-about **NEW** M-Scope . . . the only dual-purpose that detects leaks **and** locates pipe. Its rugged, highly efficient electronic circuit, plus ease of use and portability, make this instrument one of the most welcome contributions to the water works industry.

Quick Facts

For greatest convenience and reliability, the M-Scope MASTER is equipped with a **built-in battery tester** for instant checking of battery condition in the field or elsewhere.

WRITE TODAY FOR SPECIFICATIONS AND PRICE!

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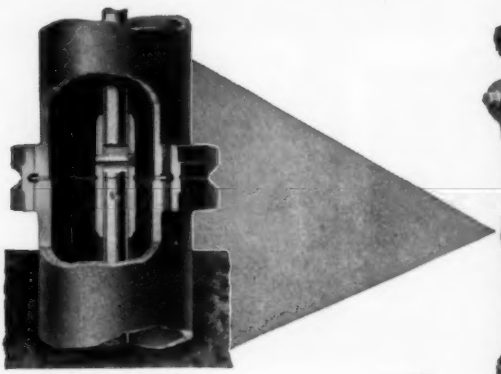
Here's How KENNEDY'S Safetop Hydrant Saves Maintenance and Repair Costs . . .



Construction of Safety Breakable Section of KENNEDY SAFETOP Fire Hydrant.

Fig. 1280
KENNEDY SAFETOP
FIRE HYDRANT

A broken KENNEDY SAFETOP . . . and all you need to repair it! When struck a smashing impact and broken, here's how the KENNEDY SAFETOP fire hydrant breaks. A clean break at the Safety Breakable Section means no damage to the main and expensive parts of the hydrant and no loss of water.

With this set of breakage repair parts, the repair job can be done by one man, with a few standard tools, without excavation. The entire repair job takes about fifteen minutes.

KENNEDY SAFETOP fire hydrants are designed and constructed with these outstanding features: Protection against flooding upon accidental breakage; maximum supply of water at nozzles available from supply main; minimum friction loss from inlet elbow to nozzle outlets; positive, complete drainage after operation to prevent freezing; leakproof valves and gaskets; easy fast inspection and renewal of operating parts.

Both KENNEDY SAFETOP and KENNEDY STANDARD fire hydrants are non-flooding compression type and are available in 4", 4½", 5" and 6" sizes. See how KENNEDY fire hydrants can save you time and money. Write today for complete details.

• *WRITE TODAY FOR COMPLETE DETAILS*

KENNEDY VALVE MFG. CO.

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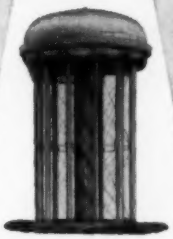

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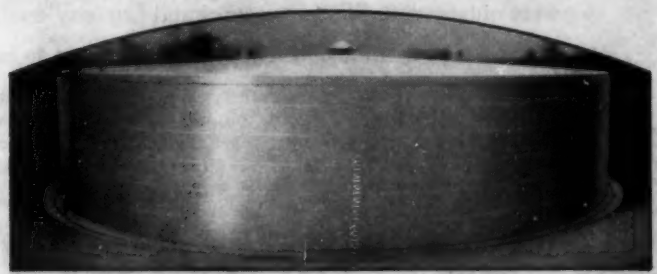
safe . . . reliable

WATER STORAGE

any size—anywhere

Hammond Steel Standpipes, Steel Reservoirs, Elevated Water Tanks, Water Spheres, Filtration and Purification Units for General Water Supply & Fire Protection Systems . . . are built to all standard codes and specifications including those of the American Water Works Association, Associated Factory Mutual Fire Insurance Companies, the National Board of Fire Underwriters, the Factory Insurance Association.



Catalog H_2O details and describes all HAMMOND Water Storage and Processing Vessels . . . Write for your copy

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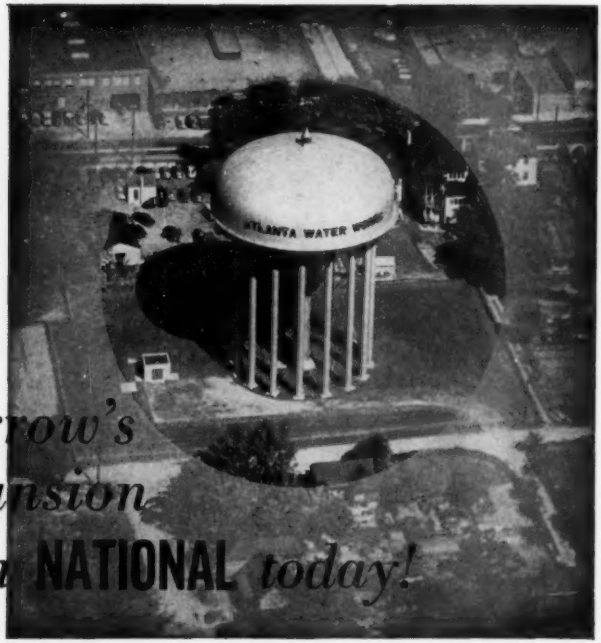

For tomorrow's expansion call in **NATIONAL** *today!*

Like Atlanta, Ga., *you* too can meet tomorrow's increased water demands with *clean water mains.* When the coefficient of sections of Atlanta's 45 year old main dropped to a low of 44, Waterworks General Manager, Paul Weir ordered National cleaning. Results were outstanding. Water pressure and capacity doubled, giving better fire protection and higher water pressure to outlying sections.

Do as other leading cities have done—let *National* cleaning provide for tomorrow's expansion without capital expenditure today! We can prove that National cleaning is an investment—not an expense.

Write us today!

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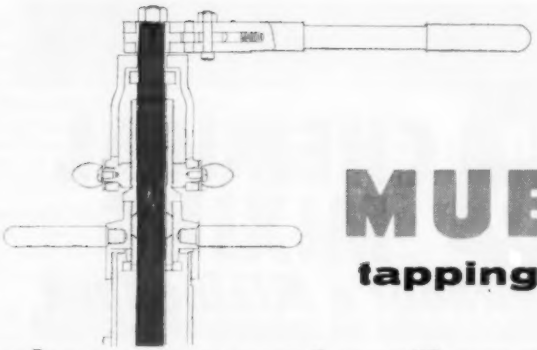
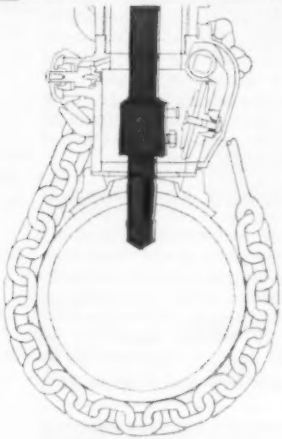


MUELLER®
tapping machines
give accurate alignment



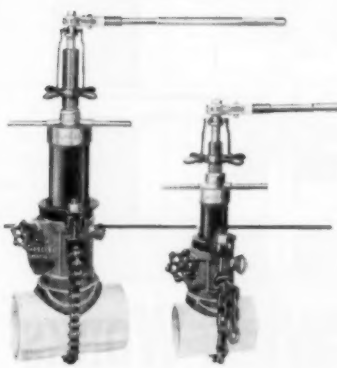
for *simple, trouble-free operation!*

Use a tapping machine with only *one* boring bar and guarantee accurate alignment, assure uniformly tapped hole and eliminate possibility of cross-threading your corporation stops.

Mueller "A-2" and "B" Tapping Machines drill and tap the main in a single operation. The combined drill and tap tool is then replaced—on the same boring bar—with the corporation stop to be inserted. Alignment is automatic and stop is inserted quickly and efficiently!

Difficulties, such as a defective thread or a tool or stop of the wrong size, are easily overcome with Mueller Tapping Machines. A flop valve between the two pressure chambers permits the boring bar and upper portion of the machine to be removed at any time during the drilling and tapping or inserting operations.

Contact your Mueller Representative, refer to your Mueller Catalog W-96 or write direct today.



"A-2" Machine inserts or removes corporation stops 1" to 2" pipe plugs 1" to 4"

"B" Machine inserts or removes corporation stops ½" to 1" pipe plugs ¾" to 2¼"

MUELLER CO.
DECATUR, ILL.

Factories at Decatur, Chattanooga, Los Angeles, In Canada Mueller, Limited, Sarnia, Ontario

Since 1857

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2-stage Homomix

The HOMOMIX gives instantaneous, violent, and uniform mixing of one or more chemicals, or gases, with water. *Immediate, total diffusion*—the most important factor for the efficient and economical addition of chemicals or gases—is obtained *without the use of a mixing tank!* For new plants it eliminates the necessity for costly mixing tank construction; for existing plants it can be effectively used to improve treatment.

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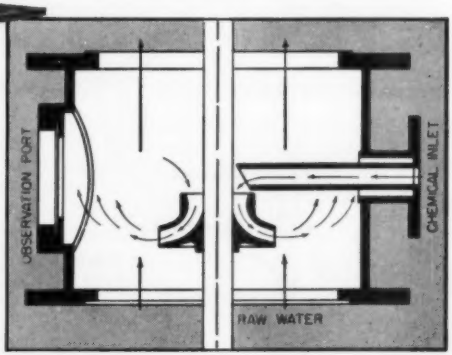

Our staff of Sanitary Engineers will cooperate with consulting and operating engineers in suggesting the process of treatment and type of equipment best suited to individual needs.

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How to select the right flow-measuring device

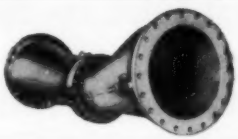
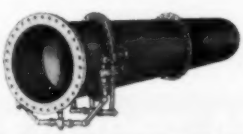
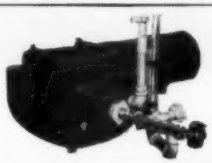
Selecting the correct device is simply a matter of choosing the one that best meets your requirements. The wide variety of Simplex Primary Elements makes this selection easy.

This table shows you which of Simplex's standard elements performs best under various flow conditions. (Not shown are Simplex primary devices of steel or concrete, designed to meet the physical limitations on special jobs.)

SIMPLEX VENTURI TUBES produce a minimum head loss—returning 85% to 90% of the differential head developed for meter operation. Since pressure differentials are measured between the main and throat sections, the tubes are smooth, true in shape and of accurate diameters to produce a stable coefficient of discharge. This gives you accuracy over wide flow ranges . . . accuracy within ±0.3% if required.

Write for Technical Bulletins. Simplex Valve & Meter Co., Dept. JA-10, 7 East Orange Street, Lancaster, Pa.

SIMPLEX®
VALVE AND METER COMPANY
VENTURI TUBES • FLUMES • METERS • GAUGES
TRANSMITTERS • CONTROLLERS • TABLES • AIR VALVES

FLOW CONDITION		SOLUTION
NORMAL WATER, AIR OR GAS FLOWS		TYPE VT—STANDARD VENTURI TUBES Cast iron with bronze bushed main piezometer holes and bronze throat liner. Flanged, bell or spigot ends. Inspection opening at throat. Special metals for high pressures or caustic liquors, corrosive gases, brines, etc. BULLETIN 005
NORMAL WATER, AIR OR GAS FLOWS		TYPE TG—INSERT TUBES AND NOZZLES Withstand high pressures. Fit inside existing lines . . . permitting light construction. This, plus *short length*, cuts costs. BULLETIN 100
SMALL FLOWS OF WATER, GASES CORROSIVE FLUIDS		TYPE TF—MINIATURE VENTURI TUBES Machining to .0005" assures accuracy. Main diameters as low as ½"; throat diameters down to .1". Welded stainless steel models for high pressures. BROCHURE
NORMAL SEWAGE, SLUDGE, TRADE WASTES		TYPE VTJ—SINGLE TAP VENTURI TUBES Single taps at main and throat have bayonet-type valve for fast cleaning. Absence of pressure belts prevents clogging. Inspection opening at throat. BULLETIN 005
NORMAL SEWAGE, SLUDGE, TRADE WASTES		TYPE VS—FOUR TAP VENTURI TUBES Four cleaning valves at main and throat can be operated manually, by air, or hydraulically to keep piezometer holes clear for top accuracy. Two hand holes on each pressure belt and inspection opening at throat. BULLETIN 005
LOW-VELOCITY SEWAGE, HEAVY WASTES		TYPE VE—ELLIPTICAL VENTURI TUBES Developed specifically to accurately measure low-velocity sewage, sludge and heavy trade wastes—under low pressures. *Flat top* prevents air binding. *Flat bottom* is self-scouring. Inspection opening at throat. BROCHURE
LOW-HEAD SEWAGE, SLUDGE, TRADE WASTES		TYPE S—PARABOLIC FLUMES Full 20:1 range for open flows. Accuracy ±2%. Flanged, bell or spigot inlet for 6 to 36" lines. Integral sediment trap, piezometer reamer, gauge glass, direct-reading flow scale. BULLETIN 801

Top: Torresdale Filter Plant: Morris Knowles, Inc., Design — McCloskey & Co., Construction

Spillway Structure, Greater Chao Phya Project — Royal Irrigation Department

Servicised Rubber Waterstop and Self-Expanding Cork Joint Filler SOLVE the SAME PROBLEM

When engineers for two widely separated projects—the Spillway Structure of the Greater Chao Phya Dam in Thailand and the Torresdale Filter Plant in Philadelphia specified premolded expansion joint and waterstop, they chose Servicised Self-Expanding Cork Joint Filler and Dumbbell Type Rubber Waterstop for optimum performance under every condition.

Servicised Self-Expanding Cork is a "maximum performance" material that will keep joint spaces filled under contraction which opens the space to more than its original size. Specially treated to enable it to expand as much as 50% beyond original thickness, Servicised Self-Expanding Cork is fully compressible, non-extruding and resilient. It is widely used in water and sewage treatment plants, canal linings, outlet works, stilling basins of dams.

Servicised Dumbbell Type Rubber Waterstop provides superior characteristics of ultimate elongation, tensile strength and retention in the concrete during contraction to insure an effective seal of joints against water pressure. Available in 2 types—Hollow Bulb and Flat, in 6", 9" and 12" widths. New Union makes field splicing a fast, simple operation. Split Type Waterstop also available.

Servicised products for the construction industry are illustrated and described in the new Servicised Catalog. Write for your copy.

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6051 WEST 65th STREET • CHICAGO 38, ILLINOIS

FOR THE BEST IN Water Meters

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ALL AMERICAN

AMERICAN METERS

Build Water Revenue

Here are some of the design features of American Meters that help you build Water Revenue:

A. A thick reinforced measuring disc is used to reduce slippage between the disc and measuring chamber wall. With this construction the clearance can be sufficient to prevent damage from grit or scale and still make a more efficient seal than is possible with a thin disc at the same clearance.

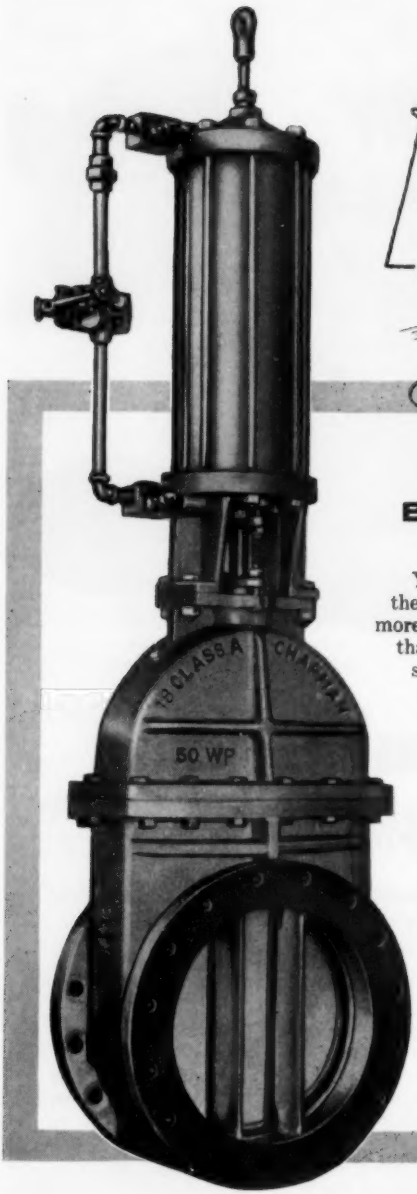
B. The seal between disc and measuring chamber is maintained in any position.

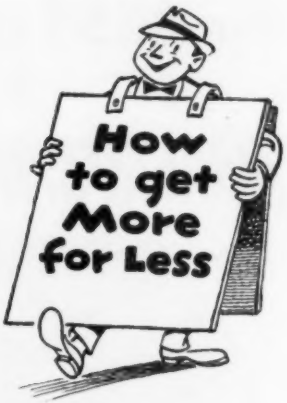
C. Absence of a thrust roller reduces friction and avoids noise.

D. Precision machining of all parts reduces friction and wear for continued measuring accuracy.

If you want full revenue from the water you supply, "go all AMERICAN."

BUFFALO METER CO. 2914 MAIN STREET BUFFALO 14, N. Y.





Specify

CHAPMAN

Beamed Waterway Gate Valve

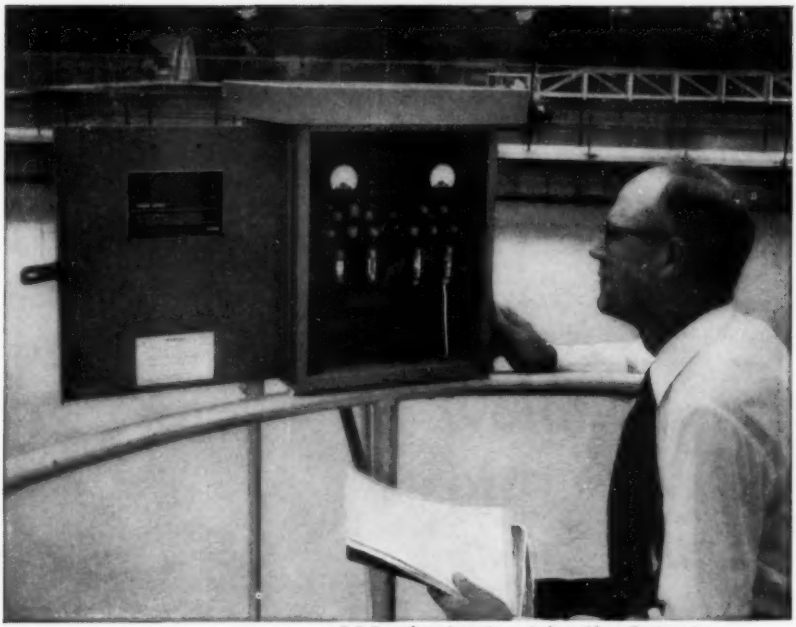
You get more bearing contact area. In the partly opened position, 6 to 10 times more bearing contact area with a Chapman than with any other double disc parallel seat or square bottom gate valve. You get long wearing bearing surfaces on the beams and downstream discs. You get smooth operation, tight seats and practically no leakage.

All this is yours for less . . . less trouble, less maintenance, less time out for repairs . . . even for decades of rugged service.

For filtration plants, wash water valve service or other places for limited throttling requirements, always specify Chapman Beamed Waterway Gate Valves. You get more for less. All standard sizes . . . any desired method of operation . . . are available. Write for our Catalog No. 45 today.

The CHAPMAN Valve Manufacturing Co.

INDIAN ORCHARD, MASSACHUSETTS



E. R. P. engineer inspects control panel for cathodic system protecting clarifiers at Louisville Water Co., Louisville, Ky.

E. R. P. CATHODIC PROTECTION

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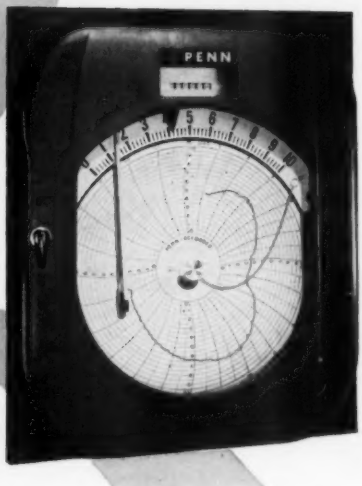

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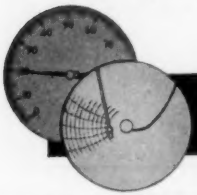

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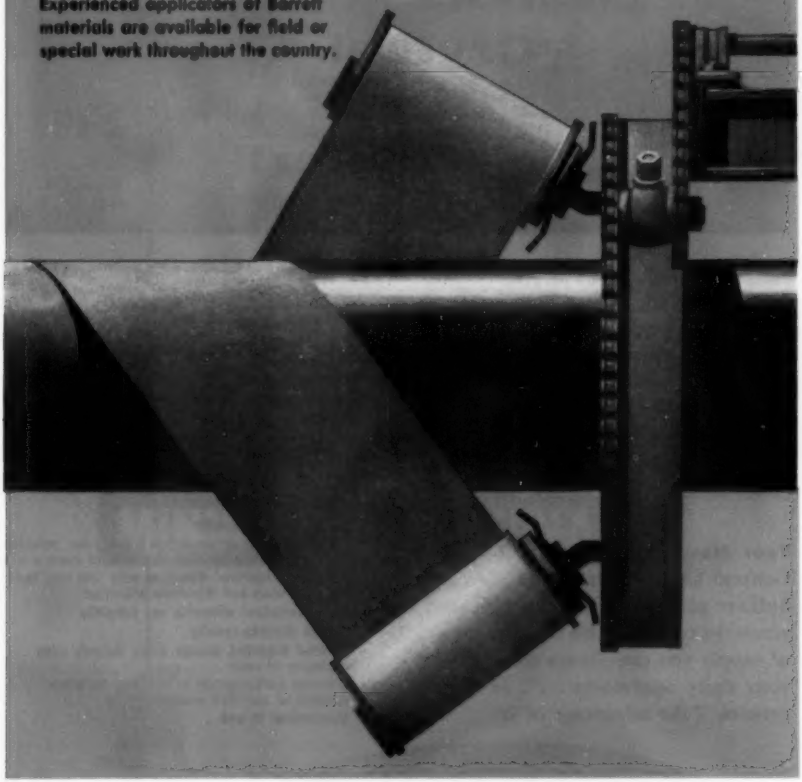

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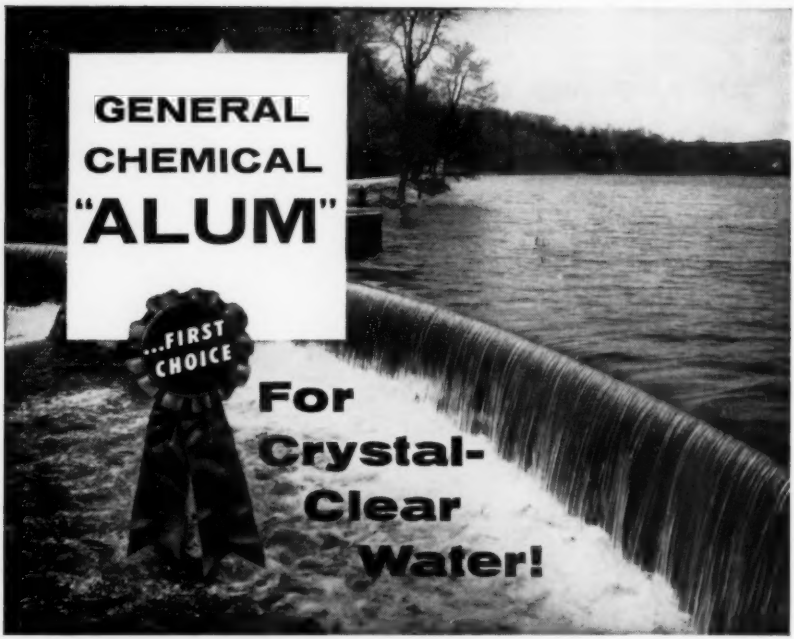

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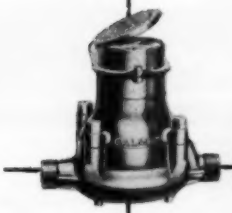

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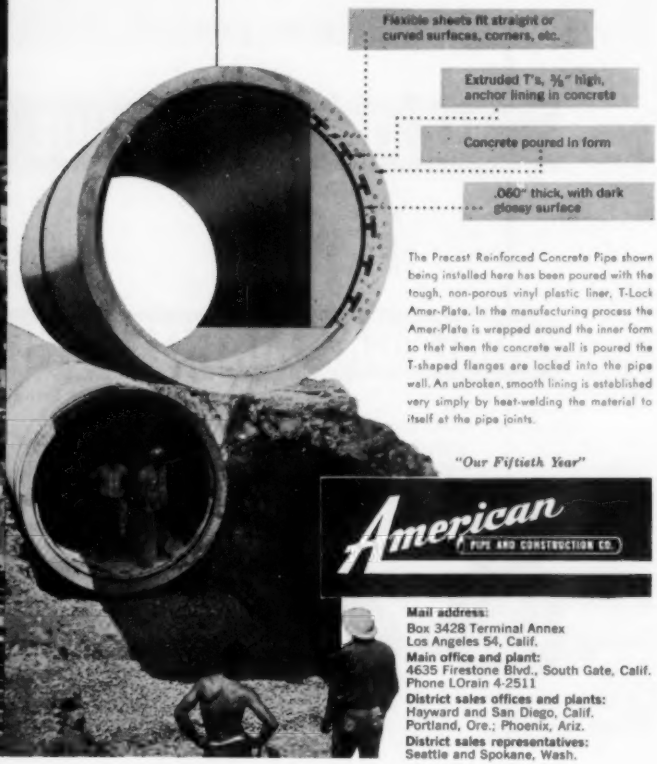
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Extruded T's, 3/8" high, anchor lining in concrete
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The Precast Reinforced Concrete Pipe shown being installed here has been poured with the tough, non-porous vinyl plastic liner, T-Lock Amer-Plate. In the manufacturing process the Amer-Plate is wrapped around the inner form so that when the concrete wall is poured the T-shaped flanges are locked into the pipe wall. An unbroken, smooth lining is established very simply by heat-welding the material to itself at the pipe joints.

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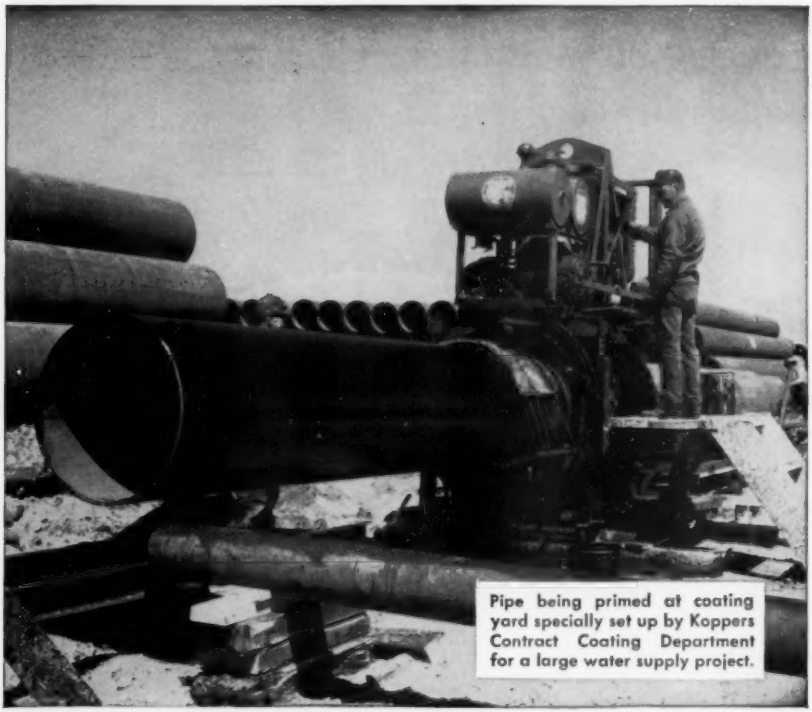

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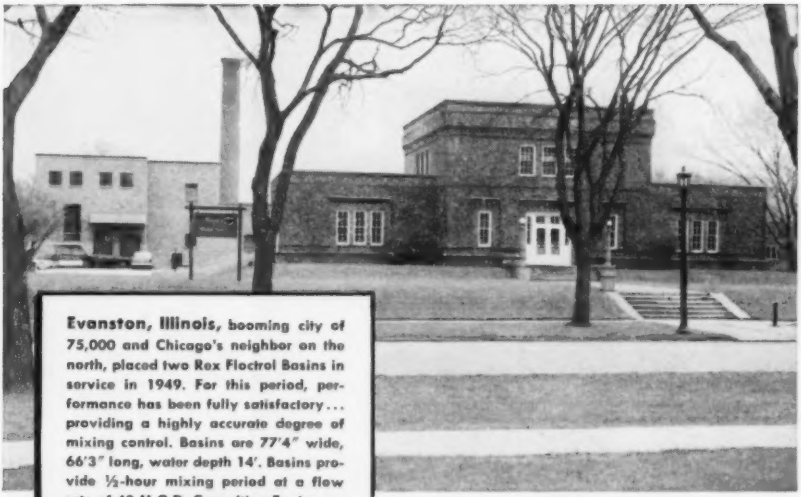

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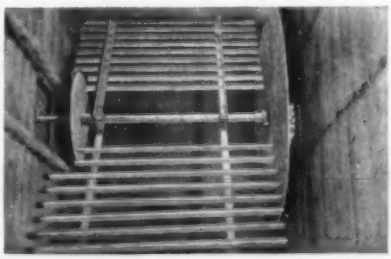

View of typical Floctrol chamber showing arrangement of paddle, rotating baffles and fixed partition walls.

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Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 49 • OCTOBER 1957 • NO. 10

Experience in Applying Fluorides

Panel Discussion

A panel discussion presented on May 16, 1957, at the Annual Conference, Atlantic City, N.J., by: John R. Baylis, Engr. of Water Purif., Dept. of Water & Sewers, Chicago, Ill.; John C. Smith, Chief, Water Supply Div., US Army Engr. Dist., Washington, D.C.; John W. Krasauskas, Chief, Plant Operations Branch, Water Supply Div., US Army Engr. Dist., Washington, D.C.; H. Christopher Medbery, Engr., Design & Water Production, Water Dept., San Francisco, Calif.; Jerome C. Zufelt, Supt., Board of Water Comrs., Sheboygan, Wis.; Albion A. Bailey, Gen. Supt. of Water Treatment, Montebello Filtration Plant, Baltimore, Md.; Elwood L. Bean, Chief, Treatment Section, Philadelphia Water Dept., Philadelphia, Pa.; James E. Kerslake, Supt. of Filtration, Water Purif. Plant, Milwaukee, Wis.; Benjamin C. Nesin, Director of Labs., Mt. Prospect Lab., Brooklyn, N.Y.; A. P. Black, Research Prof. of Chemistry, Univ. of Florida, Gainesville, Fla.; Marshall P. Crabill, Vice-Pres., Indianapolis Water Co., Indianapolis, Ind.; Attmore E. Griffin, Chlorination Consultant, Tech. Service Div., Wallace & Tiernan Inc., Belleville, N.J.; and Robert S. Phillips, Asst. Supt., Charlotte Water Dept., Charlotte, N.C.

Introduction—*John R. Baylis*

FLUORIDATION is one of the most controversial issues in the water supply field at the present time. It is the aim in this series of discussions to steer clear of the controversial aspects, however, and confine the remarks to problems of handling and applying the fluorides and to the action of the material in the distribution system.

Several suitable compounds are available for use in fluoridating water, the most common being sodium silicofluoride, sodium fluoride, and hydrofluosilicic acid. The first two of these materials are commercially available in the solid form, and the last is available in the liquid form.

Problems which are important in regard to the public are those related

to the application of the material at a constant and desired rate. Another subject requiring consideration is that of the persistence of the fluoride throughout the distribution system. Differences of opinion have arisen in regard to this latter question. As is well known, negative ions are concentrated within the tubercles in a corroded pipe and it is likely that some of the fluoride would be concentrated there along with sulfate and chloride ions. How much will be concentrated is a factor to be determined, as is the question of whether there is any possible way in which such concentrations will cause water consumers to receive at times more fluoride than they should.

The above questions offer material for this panel discussion. They are not necessarily new questions, but they are timely questions and basic to any discussion of fluoridation.

Representative Cities

All cities represented in this discussion, with the exception of New York, have had experience in the application of fluorides to public water supplies.

Washington, D.C., began applying fluoride in June 1952, following appeal by local civic organizations, recommendation by the Board of Commissioners and health officials, and subsequent approval by Congress. The chemical used is sodium silicofluoride.

San Francisco, the first major city in the west to adopt fluoridation, began with a partial program in August 1952. Plants were first constructed in two locations treating a total average flow of about 42 mgd. The program was later expanded and in July 1955, following construction of additional facilities, all water supplied to San Francisco and most of the peninsula was treated with fluoride. Treatment is from three different stations adding sodium silicofluoride directly into four different transmission lines just below principal storage and impounding reservoirs on the peninsula. Total flows treated now average about 100 mgd.

Sheboygan, Wis., began treatment of its water with fluoride in February 1946. The material used is sodium fluoride.

In *Baltimore, Md.*, dental officials of the health department first presented the idea of fluoridation to the mayor and city council. In November 1950 a resolution was adopted by that body authorizing an investigation as to the advisability of using fluorides and the best source and method of application. After this preliminary work was completed and the findings presented, a resolution authorizing its use was adopted in March 1952. Immediately following this, objections were raised by various individuals and associations, and a temporary injunction restraining use of fluoride was obtained. After hearings before the court the injunction was dissolved, and the application of hydrofluosilicic acid was started on Nov. 26, 1952.

Philadelphia has been adding fluoride to its water since September 1954, feeding hydrofluosilicic acid without dilution into the filter effluent supply.

Milwaukee, Wis., water officials proposed in 1953 to use sodium silicofluoride as the source of fluorine for the prevention of tooth decay. A referendum was held in April, and the result was about 93,000 for and 58,000 against fluoridation. After considerable discussion the aldermen approved the addition of fluoride by a vote of fifteen to twelve. After the application of fluoride was started in July 1953, the matter was taken to court and the resulting decision permitted the city to continue the application.

In *Indianapolis,* fluoridation began in August 1951, and is continuing at the present time. The city is served by two separated treatment plants, each having its own source of supply. The White River treatment plant and the Riverside pumping station deliver water to approximately two-thirds of the city, and the Fall Creek treatment plant and pumping station deliver to the balance. The distribution system is closed off along definite boundary lines, so that the two supplies are normally completely divorced. Sodium silicofluoride is the material used.

In *Charlotte, N.C.,* the fluoridation program has been underway since April 1949. Both sodium fluoride and sodium silicofluoride have been used.

In *Chicago,* water supplied to the city and its 54 suburbs is now being fluoridated with hydrofluosilicic acid, applied at three stations: the South District Filtration Plant, the Chicago Avenue Pumping Station, and the Lake View Pumping Station. Equipment for applying the fluoride has been in service since May 1, 1956, at the filtration plant and since Aug. 1, 1956, at the pumping stations.

New York City does *not* apply fluoride to its water supplies; nevertheless officials there have engaged in a thorough investigation of the matter. Opinions expressed in this discussion have been drawn from their findings and represent some of the ideas being developed for a formal departmental report.

The discussion is presented in four categories: [1] physical characteristics of fluorides; [2] observed effects upon health of employees; [3] accuracy of feeding devices; and [4] persistence of fluoride throughout the distribution systems.

Physical Characteristics of Fluorides

John C. Smith

The chemical applied for water supply fluoridation in Washington, D.C., is sodium silicofluoride. Pneumatic equipment for conveying the chemical from the 400-lb shipping drums to an existing storage bin and parallel dry feeders with pertinent dissolving tanks for applying fluorides to the water were installed at the Dalecarlia rapid sand filter plant. It was considered that this single installation for fluoridating the entire water supply processed at the two filter plants serving the city would effect operation economies, reduce occupational health hazards, and facilitate accuracy of fluoride application.

The two gravimetric feeders installed to serve the individual filter plants feed the chemical to within approximately 1 per cent of the set rates. One feeder treats Dalecarlia filtered water. The second applies fluoride solution to the alum-treated water flowing past the Dalecarlia plant in a 10-ft diameter, 2-mile long conduit en route to the McMillan slow sand filter plant. Figure 1 is a vicinity map which shows the two filtration plants and some of the other water supply system facilities. Weigh tests are made weekly to check the accuracy of application. Water required for dissolving the chemical is measured with rotameters. The resultant solution from the feeder tanks to the points of application is delivered through plastic pipelines. Figure 2 is a photograph of the sodium silicofluoride gravimetric feeders, solution tanks, electric control panel, and rotameter assembly.

Hourly readings of the amounts of fluoride applied to measured quantities of water flow are recorded. These recordings are used to calculate dosage in parts per million to the water during processing operations.

John W. Krasauskas

After favorable reaction to fluoridation in Washington, D.C., preliminary studies were initiated to select the fluoridating agent. Sodium silicofluoride

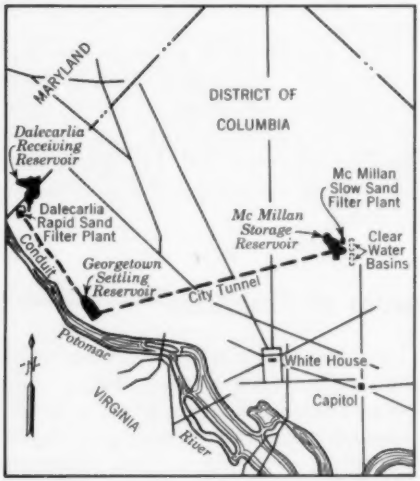

Fig. 1. Water System Facilities in Washington, D.C.

was chosen on the basis of cost and reliability of supply. Since this chemical is a dry powder which is poisonous if ingested or inhaled internally and irritating to the eyes and skin, a conveying system had to be selected which would eliminate the dust hazard during handling and storage. Upon due consideration pneumatic conveying was selected.

Handling and Conveying

The sodium silicofluoride is shipped in 400-lb drums in trailer truck load quantities of 30,000 lb per delivery. An average total of 900,000 lb is unloaded annually.

The drums are received in a scale room of the Tower Building (Fig. 3) where they are opened by one man, the pneumatic hose nozzle immediately inserted by another man, and the chemical raised vertically to the top of the tower into a concrete storage bin, using pneumatic equipment. The nozzle of the conveyor is always under vacuum, and when placed in the drum empties it completely before the hose is removed, thereby eliminating the toxic dust which might emanate from the drum to contaminate the crew. Up to the present time there has been no evidence that there is any toxic hazard in conveying the fluoride chemical in this manner.

For additional protection, the employees engaged in this unloading operation wear cotton coveralls, rubber gloves, suitable mask respirators approved by the US Bureau of Mines, dust proof goggles, and a cotton cap head covering (Fig. 4).

After unloading the fluoride each individual in the crew removes and places his protective clothing at a preset collection point, from which it is picked up by a designated person who is charged with the duty to send the contaminated gear to the laundry for cleaning and to store the clean garments for reissue after return.

Respirators are cleaned with a damp cloth, the filter is replaced, and they are returned to the carton in which they were received. Goggles are also wiped with a damp cloth, dried, and

returned to the original box. Rubber gloves are washed and dried. All equipment other than cotton garments which are laundered is turned in to the foreman in charge, who reissues the equipment whenever necessary. Equipment reused by the same individual is reissued without treatment, but when it is to be used by another individual it is always sterilized before issue.

No problem is experienced with drum disposal since after they are unloaded, the drums are returned to the seller for credit and reuse.

From the storage bin the chemical flows by gravity through closed dust-proof chutes into the weigh hoppers of the dry-feed machines, which are equipped with various safety devices to prevent overfilling and dust collectors to prevent the escape of fluoride dust to the ambient air. From the hoppers the chemical is measured by the dry-feed machines into a solution box, where it is dissolved and transported in a closed plastic pipe system to the point of application.

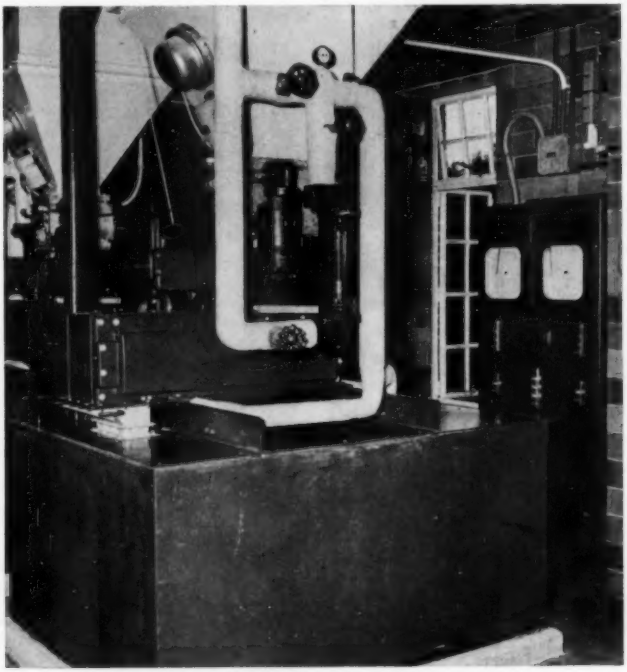

Fig. 2. Feeding Apparatus, Washington, D.C.

Shown are the gravimetric feeders, solution tanks, electric control panel, and rotameter assembly.

H. Christopher Medbery——

All stations in San Francisco are fully automatic and are equipped with

loss-in-weight gravimetric feeders with auxiliary hoppers at floor level, from which feeder hoppers are filled automatically via a screw conveyor. Sodium silicofluoride, purchased on a 6-month or annual award basis and delivered in carload lots of 100-lb bags,

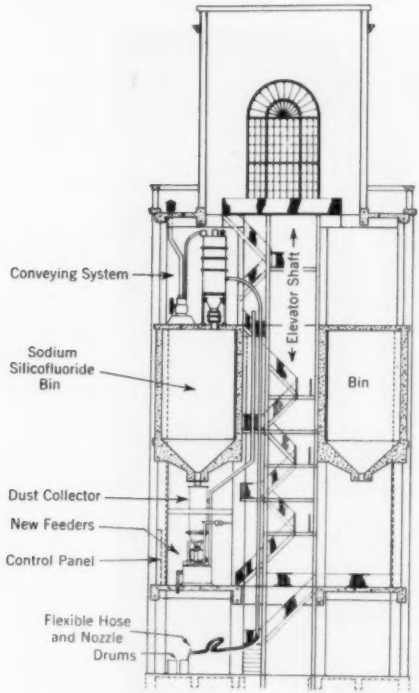

Fig. 3. Tower Building, Washington, D.C.

This cross-section drawing shows the location of the various units for receiving fluoride chemicals, storing them, and delivering them to the dry-feed machines.

is used in all stations. Feed rates are controlled automatically from venturi meters and the solution is pumped into transmission lines by centrifugal pumps with aluminum bronze impellers, and stainless steel shafts equipped with ceramic-on-ceramic seals, flushed continuously from the outside with fresh water.

The plants were designed ultra-conservatively from the standpoint of prevention of any overfeeding, and the feeders will shut down if the equipment overfeeds or underfeeds, the water supply fails, the screw conveyor fails to pick up material, the screw conveyor overloads the hopper, or if the flows drop below a predetermined setting.

Albion A. Bailey

The use of various compounds was studied in Baltimore, and hydrofluosilicic acid was selected as the best for use, from the facts that: [1] the acid was readily available from local manufacturers of superphosphates; and [2] it required less equipment and labor for its application. The acid is hauled by a city-owned truck from the manufacturer's plant and stored in rubber lined tanks at each filtration plant.

Originally, proportioning pumps were used, but due to the fact that these were of a plunger type, requiring packing, and also that the method of setting the stroke would not give close control, they were finally abandoned. Further trouble with these pumps came from sticking of the valves. This was caused by oil, which was necessary for the lubrication of the packing.

The original equipment cost $12,939.35 and since installation in 1952, $1,300.00 has been spent on replacement of equipment. Little trouble with mechanical failures is anticipated in the future.

The acid costs $55.43 per ton at the producer's plant, and the cost of hauling and handling is $1.10 per ton. As no extra operating nor laboratory personnel are required, this represents the total operating cost of fluoridating of

200 mgd—$82,042.49 for the year 1956, with a maintenance cost of $450.

Elwood L. Bean

Hydrofluosilicic acid for Philadelphia water is purchased from two sources, approximately one-half from each.

Fig. 4. Employees Handling Fluoride

Shown is the protective apparel worn by Washington, D.C., employees who handle the fluoride chemical.

Acid is delivered from both sources by a single hauling firm, using 3,000-gal, rubber-lined tank trucks, with air compressors for delivery to storage tanks elevated above the ground.

When designing the storage, officials of this trucking firm insisted that for unloading, overhead piping should be provided, with swivel joints, and with split screw couplings—one half to be mounted on their truck outlet, the other half on the end of the swinging pipe, so that the pipe could be adjusted over their outlet and the coupling quickly completed. They objected to use of hose connection as hazardous. The drivers, however, have refused to use the coupling, insisting on using hose to connect to the 2-in. fill pipe.

Short interruptions of application have resulted from a serious fire in one of the supplying plants, a strike in a supplying plant, and two strikes at the hauling firm. On three occasions, including the time of the fire, one supplying plant has assisted the other to meet requested deliveries. At no time has one of the treatment plants been without supply for more than 3 days.

Since the percentage strength of the material is not of importance in the feeding method, bid specifications allow the supplier to say what strength he will deliver. He must, however, maintain the percentage of the acid in the solution within limits of $\pm$ 0.5 per cent on all deliveries, to avoid variations in strength in storage tanks and consequent variability in feed rates. The solution delivered by one supplier contains 36.0 per cent, the other 25.5 per cent of acid. The supplier takes a sample when loading the truck, makes an analysis, and phones the results to the plant the same day as delivered. At the plant a sample is checked, by specific gravity or more exact analysis. The supplier's analyses are usually reliable, and payment is based on certified load weight and the analyses.

Corrosivity

In 2–3 years of use nothing has developed to indicate any effect on rubber

hose, plastic pipe, plastic heads, rubber valves, or diaphragms of standard model diaphragm pumps. Some particles of rubber are now being received in the liquid, and investigation is being made to determine if these are the result of decomposition of linings of supplier's tanks or the delivery trucks. Difficulties were very quickly encountered in plastic-lined ferrous pipe with hub and plastic flanges, where the lining was

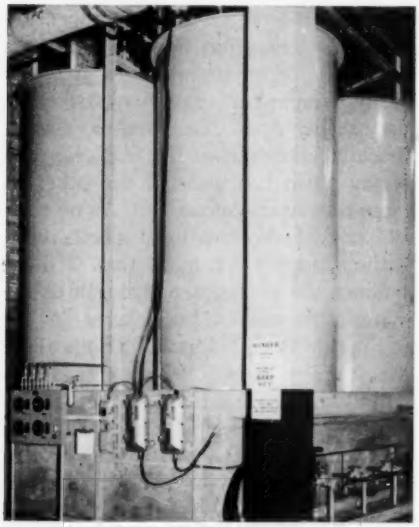

Fig. 5. Rubber-Lined Acid Storage Tanks, Chicago

penetrated in cutting for the hubs, the pipe not being exactly circular. All such piping has been replaced by plastic pipe. Elevation gages of diaphragm type were installed with metal diaphragm boxes. The box linings were not of suitable material, and the boxes were quickly destroyed.

Auxiliary feed tanks with capacity for a 1-day application were installed without venting to the outside. When the tanks were filled, the fumes over the liquid were discharged to the room, and windows soon became well etched.

James E. Kerslake

The total cost of the fluoridation equipment installed in Milwaukee was $22,667.62. This included costs for labor, handled by the water purification maintenance crew. An existing empty storage bunker was utilized, and a steel bunker with straight sides was built within the empty bunker. A special mechanism was installed, the operation of which makes it unnecessary for a man to enter the bunker to empty it (*1*).

The storage hopper has a capacity of 40,000 lb. From the storage hopper the material drops by gravity to a feed hopper with a capacity of 2,000 lb. Between the feed hopper and the dry feed machine there is a flood valve to prevent overfeeding. There are two feed hoppers and two dry-feed machines. The machines are of the belt feed gravimetric type, each having a capacity of 250 lb per hour and used alternately. When using a 12-lb per million gallon dose, each machine is capable of treating water at a 500-mgd rate. From the machine the material falls into a stainless steel vortex bowl, from which it is conveyed either in solution or suspension to the point of application.

Reference

1. Weir, W. V., et al. Fluoridation Experiences From a Manager's Viewpoint —Panel Discussion. *Jour. AWWA*, **44**:595 (Jul. 1952).

John R. Baylis

At the South District Filtration Plant in Chicago, hydrofluosilicic acid is received in carload lots. Provision

also is made for truck unloading, should the contractor choose to deliver by tank truck. Railroad tracks are not available at the Chicago Avenue and Lake View pumping stations, and truck deliveries are therefore necessary.

When delivery is made by railroad car, the contents are unloaded into four rubber-lined steel receiving tanks located below the railroad tracks (Fig. 5). Each receiving tank has a capacity of about 6,000 gal. From the receiving tanks the liquid is pumped up to a feeding tank located on an upper floor (Fig. 6). This tank is made of steel, and was rubber-lined in place.

Two 10,000-gal rubber-lined steel tanks were installed at the Chicago Avenue pumping station, and one tank of 10,000-gal capacity was installed at the Lake View pumping station.

A three-head, variable speed pump is used in the filtration plant for feeding material into the three plant mixing basins. At the two pumping station plants, solution feeding machines are used, with centrifugal pumps to force the hydrofluosilicic acid into the water tunnels. The Chicago Avenue station adds the fluoride material to the water in the Chicago Avenue tunnel system. This system supplies water to five pumping stations. At Lake View, two application points are necessary: one into the Wilson Avenue tunnel system, and the other into the water that is pumped by the Lake View pumping station. The Wilson Avenue tunnel system supplies three pumping stations on the north side of Chicago.

An acid pump is used to pump the concentrated material from the receiving tanks to the feeding tank at the filtration plant. Plastic piping is used at all the stations. Figure 6 illustrates the feeding process.

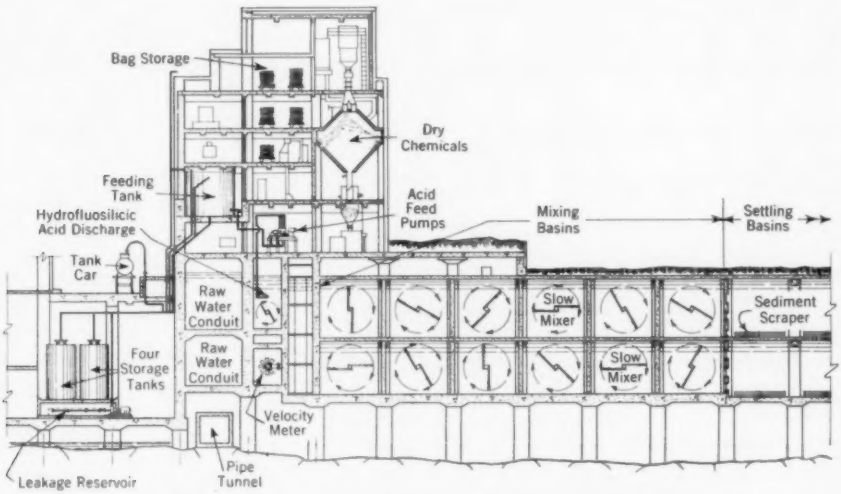

Fig. 6. South District Filtration Plant, Chicago, Ill.

This cross-section view diagrams the method by which hydrofluosilicic acid is received, stored, and fed into the Chicago water supply.

The equipment at the filtration plant has been in service since May 1, 1956, and at the pumping stations since Aug. 1, 1956. Tests are made on the water after treatment near the points of application as well as at points throughout the distribution system. No difficulty has been encountered in applying the hydrofluosilicic acid to the water in the amount desired. One of the contractors for hydrofluosilicic acid did not have enough material stored to last through the nonproductive season in the early part of 1957. Most of the fluoride produced in the United States is a byproduct from the manufacturer of acid phosphate for the fertilizer industry, or the manufacturer of phosphoric acid. Operation of fertilizer plants is at least partly seasonal. It is hoped that ample provision will soon be made to store enough material during summer months for winter use.

Application of fluoride to the raw water in the mixing basins at the filtration plant is contrary to practice at most plants. Very little fluoride, however, is lost in feeding into the mixing basin instead of into the filtered water.

Observed Effects Upon Health of Employees

John W. Krasauskas

In Washington, there have been previous health examinations of the unloading crew (Fig. 4), but they did not include complete blood, urine, and X-ray analyses. Since fluoridation of the District of Columbia water supply had been in effect for 5 years, it was decided to check the health of the handling crew exhaustively to determine whether current protective measures had been and are adequate.

The study was conducted in response to a request by the Water Supply Division, US Army Engineer District of Washington to the USPHS for medical studies of five men who have been actively concerned in the routine handling of sodium silicofluoride for the past 5 years. The purpose of the examination was to determine through means of complete laboratory X-ray examinations and urinalyses whether any detrimental effects due to handling fluoride, using current protective measures, had occurred during the 5-year fluoridation period. The current study is novel in the water industry since this type of study has previously been applied only to areas where persons have ingested water containing large quantities of natural fluoride or in industrial and mining areas where exposure to fluoride dust is a natural hazard.

Procedure and Method

The procedures used in the present evaluation are identical with those employed in the Bartlett-Cameron, Tex., 10-year study by the USPHS. In addition, this study made analyses of composite 24-hr urine specimens for fluoride content.

Time was a restrictive element in this study, and, therefore, this report concerns the result of laboratory blood, urine, and X-ray analyses only. It is contemplated that identical follow-up studies including medical histories, physical, dental, and dental X-ray examinations will be made on an annual basis on these same men, thereby yielding long-range information on a practical problem.

Blood and composite 24-hr urine samples for fluoride analyses were collected from the five men. Also, X-ray

views were taken of the lumbar spine and pelvis showing the proximal one-third of the femur, because they constitute areas in which the earliest evidence of fluoride effect can be seen in the human body.

Report of Findings

Hematology, hemoglobin, hematocrit, and red blood count fell within the normal range in all five cases. The white cell count for two individuals was slightly below the normal range,

TABLE 1

Results of Physical Examinations of Fluoride Handling Crew, Washington, D.C.

Item	Normal Range	Individual				
		1	2	3	4	5
Age	—	32	57	49	52	35
Sex	—	M	M	M	M	M
Race	—	N	N	N	N	N
Hematology						
White blood corpuscles	5,000–10,000	3,800	7,200	4,000	4,700	7,400
Neutrophiles	60–70	55	58	65	53	59
Lymphocytes	30–40	36	36	30	40	32
Mesophiles	3–9	7	3	5	5	8
Eosinophiles	0.5–4.0	2	3	—	2	1
Basophiles	1.0	—	—	—	—	—
Red blood cells	4.5–6.5	5.52	5.03	4.31	4.85	5.09
Hemoglobin	13–17	16.5	14.1	15.5	14.8	16.1
Hematocrit—*per cent*	40–47	48.5	42.0	46.5	45.0	48.0
Sedimentation rate	0–10	12	54	40	11	12
Mean corpuscular vol.—red cells	88–98	91	84	104	91	95
Mean corpuscular hemoglobin	27–31	31	28	36	31	32
Mean corpuscular hemoglobin concentration	32–40	35	34	35	34	34
Blood Chemistry						
Calcium—*mg/100 ml*	9–11	10.4	10.5	9.8	10.4	10.0
Phosphorus—*mg/100 ml*	2.4–4.7	2.7	3.7	3.5	3.2	3.2
Total protein—*g/100 ml*	5–8	7.4	7.6	6.5	7.1	7.4
Albumen-globulin ratio	1.1–1.2:1	1.06:1	0.95:1	1.24:1	1.22:1	1.11:1
Cholesterol—*mg/100 ml*	150–250	202	298	202	245	215
Urinalysis						
Reaction—pH	3–8	6	6	6	5	5
Specific gravity	1.010–1.025	1.017	1.013	1.022	1.022	1.022
Albumen	negative	neg.	neg.	neg.	neg.	neg.
Sugar	negative	neg.	neg.	neg.	neg.	neg.
Microanalysis	few	rare	few	few	few	none
24-hr fluoride concentration—*ppm*	—	0.74	1.05	1.05	0.78	1.15

but not significantly so, and the remaining cases could be considered normal. Differential counts in all instances were within the normal range. Sedimentation rate was slightly elevated in the case of two individuals, and X rays indicated a slight degree of arthritis in keeping with their ages. Table 1 summarizes the results.

Blood calcium, phosphorous, total protein and albumen-globulin ratio were within normal range in all cases. Total cholesterol was slightly elevated in one case, but this is not related to fluoride exposure.

Specific attention in the X rays was paid to the lumbar spine, sacrum, pelvis, trochanters, and femur. Area of increased bone density or coarsened trabeculation with calcification of ligaments are the most prominent roentgen findings associated with fluoride exposure. X rays of the five individuals did not show any findings that could be directly associated with fluoride exposure.

All of these men were of large stature, and the roentgen findings were in keeping with this factor. In several instances spurs and hypertrophic change normally seen in the course of routine examination were present, but not to any unusual degree.

Routine pH, specific gravity, albumen, sugar, and microscopic examination was done in each urinalysis. Findings were not unusual, except that the flouride excretion of individual No. 5 exceeded the normal content of the Washington, D.C., water supply. This indicates an ingestion of fluorides from sources other than the water supply.

Summary

In no instance did there appear to be any single factor common to the five men which might be indicative of fluoride effect. From information obtained from the various examinations and particularly the X-ray negatives, there appeared to be no physical nor functional findings that could be associated with fluoride exposure. Therefore, it is assumed that no harm has resulted from the frequent handling of large quantities of sodium silicofluoride over a 5-year period.

The number of men involved in this study is small, and it would be desirable to have additional numbers in the series. The very nature of the unloading process is such, however, that it would be difficult to have available sufficiently large numbers of individuals to establish a study on a strictly numerical basis. The disadvantage of numbers is nullified by the fact that repeated studies of the same individuals over specified intervals are contemplated. Therefore, each man becomes his own control and establishes validity in terms of end results.

It can be concluded, therefore, that the method of storing and handling fluoride and the measures utilized to protect the handling crew are adequate.

Acknowledgment

The author is indebted to Nicholas C. Leone, M.D., Chief, Medical Investigations, National Institute for Dental Research, Bethesda, Md., for the extensive laboratory and X-ray examinations, and to F. B. Maier, Sanitary Engineer Director, USPHS, Bethesda, Md., for fluoride analyses of the 24-hr composite urine samples.

H. Christopher Medbery ——

In San Francisco, treatment stations are equipped with dust collectors, and employees make regular use of gloves and dust respirators while filling hop-

pers. No deleterious effects on employees have been noted to date.

Jerome C. Zufelt

No adverse effects upon the health of employees handling the sodium fluoride have been observed in Sheboygan. Each operator has his own approved dust mask and is required to use it when filling the hopper. Rubber gauntlet gloves are also worn. A vacuum dust collection device is attached to the feed machine hopper to prevent dust from rising into the room. Fluoride concentrations in urine below 2.0 ppm indicate that no appreciable amount of this element is being stored in the body.

In 1949 and 1950 urine samples of the plant operators (and of office employees as controls) were submitted to the State Board of Health Laboratory of Hygiene for analysis. In 1949 the average fluoride content for plant operators was 0.72 ppm while the office people not at the filter plant averaged 0.31 ppm. In 1950 these values were 1.07 and 0.93 ppm respectively. In April 1957 a third set of samples was submitted and the results were 1.33 and 0.70 ppm respectively. Only two of the operators have been with the department through all three samplings. One of these showed 1.58 in 1949, 1.40 in 1950, and 1.00 ppm in 1957. The other showed 0.52 in 1949, 0.90 in 1950, and 1.70 ppm in 1957.

Albion A. Bailey

With the use of hydrofluosilicic acid in Baltimore, no health problem is present, as all handling of the acid is in closed containers or piping. Unless it is necessary to dismantle some part of the equipment for maintenance or replacement, there is no need for personnel to come in contact with the acid.

Elwood L. Bean

Of the available materials hydrofluosilicic acid is by far the least hazardous. There is, of course, no dust for employees to breathe and there is no occasion, with a properly vented installation, for employees to breathe any fumes whatsoever. In case of break or spillage one might breathe the room atmosphere for considerable periods of time without harm. The material is not harmful on the skin, if washed away within a reasonable period. In one case in Philadelphia a leak in the pressure discharge of a pump squirted the 36 per cent material full in the eyes of a mechanic. His eyes were washed with water, and he was taken to a hospital where they were again washed, the treatment being repeated the following day. No ill effects have ever been evidenced.

James E. Kerslake

Dust masks and rubber gloves for handling fluoride are furnished by the city of Milwaukee. Each handler has his own individual dust mask. The first type used was a face mask, which was uncomfortable and could not be worn over glasses. A hood type is now being used. The hood protects the neck and shoulders. It is made of dynel and has a vinyl lens; the mouthpiece contains a dust filter. The individual parts can be purchased separately if desired.

Palms of the rubber gloves are corrugated to prevent the paper bags containing sodium silicofluoride from slipping from the grasp of the handler. A shipment is received every other week,

and material required is dumped once each week into the storage bunker.

Benjamin C. Nesin

Although New York City does not fluoridate its water, there is one point that should be made concerning the hazard potential related to employees handling fluoride at the treatment works. There is no question that the handling of fluoride produces an occupational hazard.

At least one case of a water supply employee being adversely affected by fluoride * has come to attention. This refers to a maintenance man who was employed in an Idaho plant, concerning whose case there is both a legal and medical file. Chronic fluoride poisoning was manifest as toxic hepatitis. The case was settled out of court, and a substantial amount was paid in award of damages.

This information is revealing from another point of view, due to the common assertion that the toxicity of fluoride is limited to the bones and bony tissues. There is evidence, however, which has been substantiated with legal awards, that the toxicity of fluoride may affect other organs of the body.

John R. Baylis

In the Chicago plants, no illness of personnel has resulted from the handling of hydrofluosilicic acid.

Accuracy of Feeding Devices

John C. Smith

General conclusions derived from data obtained and experiences gained through the 5-year program of fluoridating the Washington, D.C., water supply show that accuracy of feeding within 1 per cent can be attained by application of sodium silicofluoride into metered quantities of water flow by means of gravimetric feeder assemblies.

In addition, except for stoppages of a few hours' duration to permit repair, testing, or adjustment to the chemical

* That there are potential hazards to water treatment employees who handle fluoride-containing chemicals has been recognized, not only by the fact that this aspect of fluoridation is a part of this panel discussion, but also by specific reference to fluoride-handing safety in the manual on Safety Practice for Water Utilities, published by the Association. Approximately a fifth of the text of this manual is made up of information concerning safe handling of activated carbon, alum, ferrous sulfate, anhydrous ammonia, ammonium sulfate, carbon dioxide, chlorine, lime, soda ash, sodium chlorite, and fluorides. In the section concerning fluorides, the following statements appear as part of the text: "All personnel handling fluorides should be given detailed safety instructions. These precautionary measures should be taken: avoid breathing fluoride dust, wash thoroughly after handling fluorides, clean up spillage. Respirators, chemical goggles, and protective clothing should be worn by all personnel handling sodium fluoride or sodium silicofluoride dust. The wearing of rubber gloves is also necessary. . . ."

To complete the author's story, the case to which he refers occurred in Coeur d'Alene, Idaho. The man who claimed damage had been, over a period of several years, the subject of critical reports made by inspectors to the state health department. His failure to observe safety precautions had been brought to the attention of the executives of the water department, who in turn failed to enforce compliance with instructions concerning safe handling of the material. It may be pointed out that fluorides are only one of the water treatment chemicals which involve possible injury to employees handling them, if these employees do not conform with instructions given them for their personal protection.—Ed.

feeders, there has been no interruption to the program since its beginning in 1952, at which time 1 ppm of fluoride content in the water was determined as the average target residual to be carried in the distribution mains.

Results of Tests

Table 2 presents a fluoridation summary for the month of June 1957 at the Dalecarlia filter plant. In Col. 7 of this table, the daily quantities in parts per million of fluoride applied to the coagulated, settled, and filtered water at the plant are enumerated. The total daily metered production of plant treated water was used to compute this fluoride application. It is believed that the fluoride feeder at Dalecarlia has applied the chemical within

TABLE 2

Fluoridation Summary for June 1957, Dalecarlia Filter Plant, Washington, D.C.

1	2	3	4	5	6	7	8	9	10	11
Day of Month	River Water Natural F^- *ppm*	Residual F^- After Coag. & Filtration *ppm*	Water Treated *mgd*	F^- Applied to Filtered Water			Total F^- Natural & Applied *ppm*	Residual F^- After Lime Treat. *ppm*	Residual F^- Water in Clear Well *ppm*	Total F^- Removed Through Processing *ppm*
				lb	*lb/mil gal*	*ppm*				
1	0.30	0.20	62.90	868	13.8	0.99	1.29	0.95	1.05	0.24
2	0.25	0.10	65.74	914	13.9	1.00	1.25	0.95	0.95	0.30
3	0.30	0.25	60.95	837	13.7	0.99	1.29	0.95	1.00	0.29
4	0.25	—	60.91	850	14.0	1.01	1.26	—	0.95	0.31
5	0.30	0.20	60.20	869	14.4	1.04	1.34	0.95	1.00	0.34
6	0.30	0.20	60.50	839	13.9	1.00	1.30	0.90	1.00	0.30
7	0.20	0.15	63.85	880	13.8	0.99	1.19	0.90	1.00	0.19
8	0.25	0.10	56.31	783	13.9	1.00	1.25	0.85	0.90	0.35
9	0.15	0.15	54.95	755	13.7	0.99	1.14	0.85	0.90	0.24
10	0.30	0.25	61.95	852	13.8	0.99	1.29	0.90	0.95	0.34
11	0.25	0.20	62.98	872	13.9	1.00	1.25	0.90	0.95	0.30
12	0.40	0.25	61.05	838	13.7	0.99	1.39	0.90	1.00	0.39
13	0.15	0.30	68.03	943	13.9	1.00	1.15	0.90	0.95	0.20
14	0.30	0.25	69.60	964	13.9	1.00	1.30	1.10	1.10	0.20
15	0.30	0.35	80.83	1126	13.9	1.00	1.30	0.90	0.90	0.40
16	0.25	0.10	84.11	1224	14.6	1.05	1.30	0.95	0.90	0.40
17	0.25	0.20	83.76	1178	14.0	1.01	1.26	0.90	0.95	0.31
18	0.30	0.25	91.09	1285	14.1	1.01	1.31	1.00	0.85	0.46
19	0.10	0.30	88.26	1256	14.2	1.02	1.12	1.00	1.05	0.07
20	0.25	0.25	84.67	1195	14.1	1.01	1.26	0.85	0.95	0.31
21	0.25	0.20	79.57	1098	13.8	0.99	1.24	0.95	1.00	0.24
22	0.25	0.20	76.90	1064	13.8	0.99	1.24	0.85	0.90	0.34
23	0.30	0.20	75.38	1050	13.9	1.00	1.30	0.85	0.85	0.45
24	0.15	0.20	79.28	1096	13.5	0.97	1.12	0.80	0.95	0.17
25	0.20	0.25	72.94	1014	13.9	1.00	1.20	1.05	0.95	0.25
26	0.30	0.20	70.66	979	13.9	1.00	1.30	0.95	1.00	0.30
27	0.20	0.25	76.12	1056	13.8	0.99	1.19	0.90	0.95	0.24
28	0.20	0.30	76.98	1081	14.0	1.01	1.21	0.90	0.95	0.26
29	0.20	0.30	78.53	1095	13.9	1.00	1.20	—	1.00	0.20
30	0.20	0.20	70.06	981	14.0	1.01	1.20	0.95	0.95	0.25
Avg	0.25	0.22						0.921	0.96	0.29

the realm of the accuracy of weight scales for weighing crystalline chemicals and of venturi meters for metering quantities of water flow when both the chemical and the water are measured at varying rates.

The weekly weigh tests indicate that the fluoride feeder at McMillan is also accurate. Although the raw-water flow rates are estimated from a curve determined from conduit flow tests and related to difference in elevation of reservoirs, the fluoride residuals of the finished water attest to the accuracy of application. The method for performing the weigh test is quoted from the procurement specifications for these two feeders:

> Each feeder shall be provided with a sampling chute for insertion of a tray, in the path of the chemical being fed. . . . Readings for accuracy determinations shall be taken at 10 per cent intervals from minimum to maximum rates. The accuracy of the feeders will be determined by weighing the amount of material fed during a 10-min period and comparing the weight obtained with the set rate on the scale. The delivery at any determination shall not vary from the set amount by more than 1 per cent.

During the period from Jan. 6, 1956, through Apr. 12, 1957, the recorded input of the fluoride chemical to the common bin from which both feeders apply the material to the water supply was 998,150 lb. The amount fed, as recorded by the two feeder totalizers, was 1,001,063 lb. The difference of 2,913 lb indicates an overall overfeed of 0.29 per cent. Two intermediate checks of less time in duration but performed during this period showed an overfeed of 0.61 per cent and an underfeed of 0.71 per cent. The results of these bulk application checks, together with the weekly tests, are helpful in making feed rate adjustments to compensate for machine wear.

The data collected to date indicate that the gravimetric feeders apply the fluoride within the accuracy of the procurement specification.

H. Christopher Medbery——

The sensitive controls have made the San Francisco plants somewhat vulnerable to the physical characteristics of the fluoride chemical and some batches have caused appreciable trouble. Chemical specifications in brief call for free-flowing, nonhygroscopic, crystalline material with 100 per cent passing a 35-mesh screen, 95 per cent passing a 100-mesh screen, and not less than 5 per cent nor more than 40 per cent passing a 325-mesh screen.

Screen specifications alone, however, will not prevent receipt of material which may cause feeding troubles, such as arching in hoppers or around the feeder screws. A recent change in specifications now requires the sieve analysis to be made using an electric sieve shaker at a dial setting of 8 for a 25-min shaking period. Tests indicate that this will eliminate a flourlike material recently received, which caused considerable trouble and yet complied with size specifications using accepted screen test methods.

No material yet received has failed to pass the moisture content specification limits, even though it may have caked or caused arching in the hopper. In general, only foreign material and material from one domestic manufacturer has given trouble due to caking, and no physical or chemical tests yet made have revealed the reason for such caking. The arching has generally resulted when using the flourlike material, and the sieve analysis may not

consistently eliminate such material on size specification requirements. There is still room for improvement in specifications to eliminate this trouble.

Other difficulties encountered are corrosion and erosion of solution pump cases and impellers and corrosion around the threads of brass fittings installed on lines leading from the solution pots to the solution pumps. Trouble seems to begin any time after a 2-year usage. Stainless steel and plastic pipe have proved very successful for carrying the sodium silicofluoride solution, and brass stopcocks are now being replaced with polyvinyl chloride stopcocks which are designed for self lubrication.

The feeding accuracy of the equipment is very good as shown by spot checks when the equipment was first placed in service and by two checks on actual material used compared with totalizer figures on the equipment. The first check showed a deviation of 0.43 per cent using 9,500 lb, and the second check showed a deviation of 0.22 per cent using 140,000 lb over a 10-month period.

Jerome C. Zufelt

In general sodium fluoride feeds well through the gravimetric loss-in-weight type of dry feeder used in Sheboygan. Some caking occurs, especially after storage and in bags on the bottom of piles. Caked material is scraped through the hopper screen during filling which pulverizes it satisfactorily. What flooding has occurred would have been prevented by a feed gate which was not available when the machine was purchased.

In 133 months (approximately 4,050 days) of operation the monthly average of daily feeds has deviated by more than 0.03 ppm in only 5 months. The daily feed has deviated by more than 0.1 ppm on 63 days, eight of which were plus and 55 minus.

The 8 plus days, no two of which were in the same month and none preceded or followed by a plus day, showed feeds in excess of the desired rate by 0.17, 0.14, 0.56, 0.20, 0.40, 2.58, 0.23 and 0.12 ppm. The 3.58-ppm feed for one day was caused by an operator's error that permitted flooding of the feeder when the hopper was filled. The bulk of the material spilled onto the floor or formed a muddy mass in the solution box and was scooped out, so it did not get into the water supply. No fluoride was fed for the balance of the day or the following day. The 4 PM and midnight plant samples showed 2.1 ppm, and at 9 AM the next day the samples showed 1.8 ppm. The plant tests then dropped off, because no fluoride was being fed. The distribution tests following this incident showed a maximum of 1.4 ppm, though a higher value might have occurred if caught at just the right time. The other 7 plus days were caused by errors in machine setting or to flooding less severe than the case explained in detail above. There have been no plus days since November 1950. There is, of course, much more concern about overfeeding of fluoride than underfeeding.

The 55 minus days varied from no feed, when the machine was out of service on a few occasions for repairs, to 0.1 ppm less than desired. Most of these were due to clogging of the feed gate, some were days preceding and following a day of no feed, a few were caused by operators' errors in machine setting, and for one 4-day period in 1955, the plant output rate exceeded the capacity of the feeder.

Albion A. Bailey

At the present time in Baltimore, hydrofluosilicic acid is pumped by a constant quantity rotary pump in which the acid only comes in contact with a plastic case and rubber liner to a small constant head tank, from which it is fed through a regulating rubber pinch valve and a rotameter to the water, the excess being returned to the storage tank. The installation has allowed very close control on the quantity used and is the simplest arrangement possible for the operators to handle.

Since this installation, the major difficulty occurred during a strike at the supplier's plant, during which time the acid was obtained from out of town. The concentration of this particular acid was 35 per cent instead of 23 per cent, which is ordinarily used and it was immediately noticed that the glass rotameter tubes were being attacked. To offset this the acid was diluted to the normal strength, but the glass was still being attacked. Further investigation showed that this acid contained at least 1 per cent of free hydrogen fluoride. By this time the glass in all rotameters was seriously damaged, but this acid was used until the strike was over and the regular supplier could again fill orders.

In order to forestall the possibility of future trouble with free hydrogen fluoride, sand has been placed in the constant head tanks so that all the acid will pass through this medium before going to the rotameter or back into the storage tank. Doing this appears to have prevented any serious reaction with the glass in the rotameter.

Elwood L. Bean

In Philadelphia treatment, hydrofluosilicic acid is fed in the strength received, without dilution, into the filter effluent water before entering filtered-water basins. The acid is stored in rubber-lined steel tanks, drawn daily into auxiliary feed tanks, then pumped by variable-stroke diaphragm pumps to application points. The auxiliary tanks are equipped with sight tubes and calibrated scales, from which the quantity fed is very accurately determined and recorded. Consistency of feeding rate by the diaphragm pumps on any nondepositing liquid, free of suspensions, is well known. This is double-checked by the calibrated scale readings. No problem has been encountered in feeding the acid.

Automatic pump operation by time cycle, in proportion to flow, is in effect on one point and will soon be installed on a second. This is, of course, very desirable in maintaining accurate feeding.

The only employee operation required is: [1] daily valve operation for filling of the auxiliary tank, [2] a few minutes every 3 hr to record the amount fed, as shown by the calibrated scale, and [3] a few moments to reset the pump stroke when required.

Dosage rate is specified by the chemist on duty, after completion of tests for the fluoride content of the filtered water. Once in each 8-hr shift the tests are completed and calculations made as to the amount of fluoride necessary to be added to raise the content slightly over 1.0 ppm. Using the analysis of the hydrofluosilicic acid being received, calculation is made and dosage specified in terms of gallons of acid per million gallons of water filtered.

Fluorides naturally present in the sources of water generally run from 0.1 to 0.3 ppm. Some removal is indicated in the treatment processes—for instance, in 1956 Belmont showed a

median of 0.15 ppm in raw and 0.13 ppm in slow sand effluents, Roxborough 0.20 and 0.13 ppm respectively, and Torresdale 0.18 and 0.13 pm respectively. The average treatment for all plants was 0.97 ppm.

Test Methods

Tests are made each 8 hr on filtered waters and final waters leaving the plants, daily on tap samples taken from 2 to 7 days each week at some twenty points in the distribution system, and occasionally at several other locations. The city health department laboratory also tests some fifteen distribution points from 2 to 5 days each week, as a double check. Tests made in the Philadelphia Water Department laboratories in 1956 by the distillation method exceeded 5,000 and by the direct method 30,000. The latter are done chiefly by the chemists on treatment control shifts; the former required most of two chemists' time.

Standard test methods have proved to be quite unsatisfactory on these waters. Tests without distillation are so erratic as to be of value only as immediate indicators as to any extreme differences. With distillation it has been necessary to modify both distillation procedures and test methods to eliminate the many interfering substances generally present in these river waters. A great amount of research has been performed by the chemists, results of which will probably be published shortly. Basically, the Megregian-Maier test is being used, following distillation, with spectrophotometers for final reading.

James E. Kerslake

To prevent caking or packing, a vibrator was installed in the Milwaukee treatment plant. This operates in synchronization with the flood valve. Prior to the installation of the vibrator, the material used to pack in the lower end of the cone-shaped feed hopper, just above the flood valve. It was also necessary to insert a tee-shaped flat plate of 26-gage galvanized steel in the control mechanism below the flood valve to prevent very fine material from spreading out on the feed belt. Whether or not this material is in solution is unknown. It is carried in solution or suspension to the point of application, and appears in solution immediately after it enters the larger body of water in the clear well.

Attmore E. Griffin

It appears that the application of fluoride-containing chemicals to water at a constant and uniform rate is an everyday routine.

Evidently the equipment used is dependable, durable, and accurate within the sphere of practicability. Should, by chance, an individual chemical feeder develop a flaw, it is well known that the manufacturer is quick to repair or replace the faulty part or to replace the entire unit if necessary. It is probably safe to say that at the present time, more than 95 per cent of the fluoridation installations perform satisfactorily from the start. This situation has been achieved by utilizing the experience gained during the early developmental stages of the process.

This rosy state of affairs did not always apply in the early days of fluoridation because the manufacturers and users were without prior experience. It sometimes seems as though the loud protest of the few represented the many. Experience, however, shows that fluoride-containing chemicals are not always uniform in physical characteristics and do not always follow the

solubility curves or data indicated in the various chemical handbooks.

Chemical Difficulties

During the period required to translate theoretical data to workable practices, the cause for much of the criticism proved to be largely chemical rather than mechanical in nature. For example, it was at first presumed that the readily available sodium fluoride should be easy to feed. Textbooks showed its solubility to be 4.0 per cent, but it was not generally realized that this was a laboratory figure probably based on a reagent grade of chemical dissolved in distilled water. No mention of time required to obtain this 4.0-per cent solution was given. Experience soon showed it to be impossible, even under seemingly ideal conditions, to obtain more than 3.5 per cent fluoride strength solution. This is a critical matter where the material is batched and applied by means of a pump. After a survey of the fluoride installations in New York State, the State Department of Health set a limit of 2.75 per cent fluoride for sodium fluoride when batched and fed by a pump.

Nearly all waters contain some calcium, and many contain a great deal. When sodium fluoride is delivered by a dry feeder to a solution tank of sufficient size and water flow characteristics to provide a fluoride concentration well within the solubility limits, a very small percentage of the fluoride may combine with calcium in the water to produce calcium fluoride, which is much less soluble than sodium fluoride.

With time, some of this may deposit on the interior of the pipes leading to the point of application. This deposit can be great enough to restrict the flow seriously. This difficulty usually can be overcome by using softened water, or by introducing proper amounts of phosphates, or by frequent cleaning. Again, this is not really a problem, just a matter of a chemical difficulty overcome by chemistry.

Hydrofluosilicic acid feeding is another example of chemistry playing tricks with the water works operator. Hydrofluosilicic acid is a liquid and is fed as a liquid. Frequently it is desirable to dilute it. Generally this can be done without difficulty, but sometimes a gel forms which clogs strainers. This can be overcome by notifying the manufacturer, who can correct the trouble by a slight change in formulation. The gel usually consists almost wholly of silica in gel form. This is another example of a chemical characteristic overcome by the application of chemical knowledge.

Operational Difficulties

It is generally accepted that the dry-feed equipment used in water purification will apply water treatment chemicals accurately and continuously within practical limits provided a chemical is of uniform physical grade, not hygroscopic, and generally recognized as feedable.

Operational difficulties have occurred when succeeding shipments, or when portions of a single shipment vary in characteristics. Lumping or caking of sodium silicofluoride for instance, can create a problem. It is not practical to incorporate a corn grinder in every dry-feed machine to chew up the lumps, but at Brantford, Ont., the sodium silicofluoride is passed through a corn grinder prior to filling the feeder hopper. This is not always necessary, but at Brantford it was found that some silicofluoride received caked under its own weight even though various lots

were identical in assay. Where lumps too large or hard to go through any feeder are present, it is again a chemical, or possibly a physical, characteristic that must be overcome.

When the fluoride solutions must be injected against pressures greater than 40 psi, pump difficulties increase in the form of abrasion and corrosion. Pumps for such back pressures are expensive, which is always a consideration. Specific examples of these general types of feeding difficulties could be cited over and over again.

In the final analysis the problems encountered in the application of fluorides to water have been largely solved by applying principles of chemistry, hydraulics, and engineering.

Robert S. Phillips

At Charlotte, N.C., both sodium fluoride and sodium silicofluoride have been used as the fluoridating chemical. Both have been fed to the water by a gravimetric loss-in-weight type feeder. At the beginning of the program the dosage was varied seasonally from approximately 0.55 ppm to 1.15 ppm (as F^-). Since early in 1954 the dosage has remained constant at approximately 0.95 ppm as recommended by the Charlotte Health Department. The fluoride is added to the combined filter effluent as it enters the clear well.

The accuracy of application of any chemical to the water is dependent on other factors besides the accuracy of the chemical feeder itself. The most important of these, perhaps, is the accuracy of the metering and control devices which are used to measure and control the quantity of water under treatment.

With the dosages used at Charlotte it can be said that the practical accuracy of combined feeding, metering, and control system varies about 3 per cent from the set dosage.

Average figures are shown in Table 3. The set rate is the theoretical dosage applied as related to the quantity of water being filtered. This is compared with the actual applied dosage based on the weight of the chemical fed as related to the total water treated. This latter figure is not corrected for shutdowns of the feeder for operating maintenance and minor repairs. It therefore is affected by errors in feeding, controlling, and measuring, except long shutdowns.

TABLE 3

Yearly Averages of Fluoride Application at Charlotte, N.C.

Year	Set Rate *ppm*	Actual Rate *ppm*
1950	0.82	0.80
1951	0.82	0.80
1952	0.89	0.87
1953	0.88	0.86
1954	0.98	0.95
1955	0.95	0.92
1956	0.87	0.84
7-yr avg	0.89	0.86

John R. Baylis

In the south district of Chicago, the water of which is filtered, the average hydrofluosilicic acid applied to the water for the period May 1, 1956 to May 1, 1957 amounted to 0.85 ppm. The amount of fluoride naturally in the water is 0.07 ppm, giving a total of 0.92 ppm. The residual fluoride in the water leaving the filtration plant averaged 0.91 ppm for the year. After passing through tunnels to the three pumping stations in the south water

district, the average fluoride at the 68th Street Pumping Station was 0.92 ppm; the average at the Roseland Pumping Station was 0.92 ppm; and the average at the Western Avenue Pumping Station was 0.93 ppm. The maximum amount of fluoride at any one time has been not more than 10 per cent above the average, indicating very uniform application of the fluoride.

—Persistence of Fluoride Throughout Distribution Systems—

John C. Smith

Observations at Washington, D.C., indicate the following conclusions concerning persistence of fluoride in the distribution system:

1. Water processing operations at the Dalecarlia rapid sand filter plant remove an amount of fluoride which is approximately equivalent to the natural amount contained in the raw water of the Potomac River.

2. Constant and extensive laboratory analyses of the water from the source of supply through the finished product in the mains are essential to accomplish maintenance of fluoride residual targets.

3. Plant-treated water fluoride residuals persist within limitations of the method of analysis to the extremities of the distribution mains, even though iron rust in suspension has been present occasionally.

4. Tubercles in old cast-iron pipe adhere firmly to the pipe walls and contain an insignificant amount of fluoride that does not dissolve in the water transmitted in the mains.

Water Processing

The data collected relative to fluoride contents of the raw water and the fluoride residual in the service reservoirs and the distribution system pipelines are studied to determine appropriate fluoride dosages. Laboratory analyses indicate that a loss of the fluoride ion is experienced in processing the water because of coagulation with alum and corrosion control with lime. Adjustments of fluoride feed are made to compensate for these losses.

Reference is made again to Table 2, which shows in Col. 3 and Col. 9 the fluoride residuals after alum coagulation and corrosion control treatments, respectively, for June 1957. Column 11 of the table shows the overall loss of fluoride due to water processing operations at Dalecarlia. The points of application for lime and fluoride are in close proximity which would seem to facilitate removal of fluoride by formation of calcium fluoride, a precipitate. Corrosion control at Dalecarlia requires the application of lime in considerable amounts to reduce the carbon dioxide content of the coagulated water and to increase the finished water alkalinity appropriately. The data collected at this time are insufficient to verify this supposition. Additional analyses of the water from this sampling point would be required to effect a determination.

A careful review of the entire Dalecarlia operating record revealed that the fluoride residual in the distribution system water approximated the amount of applied fluoride. Occasional plus and minus differences indicated slight discrepancies between the applied fluorides and the residual fluoride in the mains but these differences were usually within the limitations of the measuring equipment and the testing methods. The amount of fluoride lost during water-processing operations ap-

proximates the content of the raw water. Table 4 indicates the average annual losses.

Laboratory Analyses

The chemical, sodium silicofluoride, furnished under biannual government procurement contracts, is analyzed chemically and physically for compliance with specification requirements. These analyses assure that the chemical applied contains the correct amount of fluoride and that deleterious or toxic materials are not present in amounts that would render the water supply unpotable.

To facilitate determination of fluoride dosages, samples of raw and processed water are composited hourly. Raw water is sampled at the point where it enters the Dalecarlia plant and treated-water samples are taken from various points in the purification processing operations of both filter plants. The fluoride ion content thereof indicates the continuity and accuracy of fluoride application. Regularly established bacteriological sampling points in the distribution system are utilized to collect five spot samples daily except on Saturdays and Sundays. The points selected represent average conditions in the distribution system as well as those at the system extremities in each of the system's seven pressure zones. Also, spot samples from the water distribution systems of Arlington County and Falls Church, Va., are analyzed.

A maximum reading in the distribution system was always found to follow a corresponding maximum in either of the two plant effluents. During the 5-year fluoridation program wherein more than 8,000 distribution system samples were analyzed, no results indicated a fluoride content greater than was contained in the filter plant effluents. The low minimum readings always followed feed equipment shutdowns.

Reports are compiled every month relative to: [1] fluoride content of hourly composited samples, and [2] distribution system fluoride analysis of spot samples. These reports are forwarded to the District of Columbia departments of Health and Sanitary Engineering for informative and documental purposes.

The health department collects samples from the distribution system and analyzes them independently. Also, one-half of each of the composited treated-water samples from both plants is submitted to the department for examination. Results of analyses are exchanged between the

TABLE 4

Fluoridation Summary by Years, Dalecarlia Filter Plant, Washington, D.C.

Year	Avg Fluoride—*ppm*			Avg Residual F^- of Water in Clear Well *ppm*	Net Loss of Natural and Applied F *ppm*	Avg Alum Added *ppm*
	Natural	Applied	Total			
1952*	0.17	1.00	1.17	1.00	0.17	22.60
1953	0.25	1.03	1.28	1.09	0.19	20.03
1954	0.25	0.97	1.22	1.01	0.21	18.83
1955	0.25	0.98	1.23	0.98	0.25	21.23
1956	0.26	0.93	1.19	0.93	0.26	21.23

* Fluoridation of Washington, D.C., water began on June 23, 1952.

two laboratories for information purposes and, if discrepancies of consequence were to be noted, corrective measures would be instigated. These duplicate laboratory analyses serve to assure the accuracy of fluoride application and to provide independent records relative to this public health service.

The Washington Aqueduct laboratory determines the fluoride content by the Megregian-Maier method and utilizes a spectrophotometer to read the results. The health department uses the modified Scott-Sanchis test and determines the results visually with standards prepared in Nessler tubes. The accuracy of the two methods is ± 0.05 ppm and ± 0.10 ppm, respectively.

The data collected during the 5-year program of laboratory analysis of the water supply from the source to the consumers indicate that the practice must be continued to maintain recommended target residuals in the mains.

Fluoride Residuals

In addition to the above analyses, samples collected concurrently with system flow tests conducted recently by the Washington, D.C., Fire Department were analyzed to determine fluorine residuals. The analyses of 50 samples from fire hydrants located in the oldest areas of the city where high iron deposits could be expected indicated the retention of fluorine content in the delivered water. There was no evidence that turbulence in these old distribution mains caused increased fluoride content in the water. The results of these analyses are shown in Table 5.

In the first sampling series, only two samples were taken from each of ten fire hydrants. In the second series, three samples were collected from each hydrant, the first obtaining the first runoff, the second after a 2-min run, and the third showing the highest turbidity visually. The particulate iron content in the sample at each fire hydrant varied from complete absence to a very high amount as observed at the same sampling point.

Samples having little or no iron rust in suspension were analyzed spectrophotometrically and the results compared with the distribution system average for the 5-day period immediately preceding the collection of the fire hydrant samples. Turbid samples were analyzed by the distillation method. The slight variation in the residuals found in the samples collected at each hydrant was within the limitations of ± 0.05 ppm of the testing method except for sample No. 1 collected Apr. 25, 1957. No unusually high readings were obtained even though some of the samples contained iron rust in suspension. These residuals corresponded to those of the plant-treated water during this same period. Consequently, it is reasonable to conclude that the fluoride residual of the plant-treated water persists therein throughout the distribution system.

Analysis of Tubercles

Since the analysis of the turbid samples mentioned above did not indicate loss of fluoride from the flowing water in encrusted old pipelines, a 6-ft long, 6-in. diameter section of tuberculated cast-iron pipe which had been installed in the early 1860's was removed and the tubercles examined for fluoride content. Since an iron content in water in excess of 0.5 ppm interferes with the Megregian-Maier method for determination of fluoride content, the distillation method was utilized to analyze 1 g of tubercle scrapings dissolved in sulfuric acid. A fluoride content of 0.35 mg was found in that sample. A

duplicate analysis yielded essentially the same result.

The tubercles adhered tightly to the cast-iron pipe, and it was necessary to scrape the pipe forcibly with a metal tool to collect the sample for analysis. Hence, it is believed that the encrustment would not be removed by turbulent water flow.

A 2-in. square of the cast-iron pipe was thoroughly cleaned of all tuberculations down to the base metal with a buffing machine. The metal was shaved, and a representative 1-g sample of the shavings was analyzed for fluoride content by the distillation method. No fluoride was found.

A possible explanation for the presence of fluoride in the encrustment mentioned above is that it was deposited from the raw water during the period of tubercle growth. It is not conceivable that all the growth occurred during the past 5 years of fluoridation. Raw settled water was applied directly to the distribution system from about 1864 until 1905, when the McMillan slow sand filter plant was constructed. Thereafter, until 1942, filtered but not coagulated river water was delivered to

TABLE 5

Persistence of Fluoride in Distribution System, Washington, D.C.

Sampling Point	Sample No. 1		Sample No. 2		Sample No. 3	
	F^- Content Found By Analysis *ppm*	Amount of Rust	F^- Content Found By Analysis *ppm*	Amount of Rust	F^- Content Found By Analysis *ppm*	Amount of Rust
	Collected on Apr. 10, 1957					
1	0.90	heavy	0.95	medium		
2	1.00	clear	0.90	slight		
3	0.90	slight	0.90	slight		
4	0.85	medium	0.90	medium		
5	0.90	medium	0.85	heavy		
6	1.00	slight	0.95	heavy		
7	0.95	very slight	0.95	very slight		
8	0.90	very slight	0.95	very slight		
9	0.90	medium	0.95	heavy		
10	0.90	heavy	0.90	medium		
	Collected on Apr. 25, 1957					
11	1.10	slight	1.15	slight	1.20	moderate
12	1.15	slight	1.10	moderate	1.15	moderate
13	1.15	medium	1.10	moderate	1.00	moderate
14	1.10	moderate	0.95	heavy	1.00	moderate
15	0.95	heavy	0.95	heavy	1.00	heavy
16	1.05	0	1.05	heavy	1.00	very heavy
17	1.05	0	1.00	slight	1.00	very heavy
18	1.00	0	1.00	slight	1.00	slight
19	1.05	heavy	1.00	moderate	1.05	heavy
20	1.00	slight	1.00	slight	1.00	moderate

the system. So, for a period of about 80 years, water flowing through this pipe carried the natural fluoride contained in Potomac River water. If it is assumed that the natural fluoride content at that time were equivalent to the present day analyses, it would be possible that natural fluoride was present in amounts as high as 0.60 ppm and in average amounts of about 0.25 ppm. Also, since fluoride has an affinity for combining with iron salts, it is conceivable that it formed an iron complex in the encrustation. Once the tubercle hardened, it sealed off the fluoride. In the distillation method of analysis, the fluoride was unlocked from the complex by dissolving the complete encrustation with sulfuric acid. The flowing water in the mains neither removes the hardened tubercles nor dissolves the entrapped fluoride significantly, as determined by analysis of iron rust in suspension drawn from of the fire hydrants.

Acknowledgments

Appreciation is expressed to the following for their assistance in the preparation of this article: John W. Krasauskas, Chief, Plant Operations Branch; Harry C. Ways, Sanitary Engineer; and laboratory personnel—all of the Water Supply Division, US Army Engineer District, Washington, D.C.

H. Christopher Medbery

Variations in test results on the persistency of material in solution throughout the San Francisco distribution system are within the accuracy of the test procedures. An average of 640 tests taken throughout the system, all beyond the terminal distribution reservoirs for principal transmission lines, showed only a 0.04-ppm variation from the average dosage actually added to the water plus the natural fluoride content. In one distribution zone entirely fed from a distribution reservoir the average of weekly tests on 50 samples collected from the outlet is within 0.01 ppm of the average of tests on 155 samples collected from points near the end of the distribution system. These tests results cover approximately a 1-year period.

Over 6,000 tests have been run on samples collected during a 5-year period. No test result has ever exceeded 1.3 ppm, with only five tests showing the above concentration and a relatively few showing concentrations as high as 1.2 ppm. Nearly all of these were near the plant outlets. Very few tests have ever exceeded 1.0 ppm within the distribution system, and none has exceeded 1.2 ppm.

Jerome C. Zufelt

To determine persistence of the added fluoride throughout the Sheboygan, Wis., distribution system, three fluoride determinations on plant tap samples are made each day, one each at midnight, 9 AM, and 4 PM. One distribution sample is brought from the plant chemist's home each morning and an additional distribution sample is picked up each day from scattered points throughout the system.

The 133 months of operation has resulted in about 7,000 tests on distribution system samples. After the average, maximum, and minimum results for each month were tabulated, all deviations from the average of 0.1 ppm or more were noted. Seventy-five such deviations were found, 26 of which were plus and 49 were minus. In all but five of these cases, the deviation also appeared in the plant tap tests, the

feed machine operation, or in most cases in both. Of the five others, four were plus and one minus, the four plus being 1.30, 1.40, 1.35, and 2.0 ppm, and the minus being 0.70 ppm. The 2.0-ppm sample came from the author's garage faucet, and the samples from the same source on the previous and following day showed no deviation.

In all other deviations, the maximum test result was 1.50 ppm and the minimum was 0.12 ppm, which occurred when no fluoride was fed.

Albion A. Bailey

The annual report for 1956 shows that the average concentration of fluorine in the effluent of Baltimore plants is 0.99 ppm with a maximum of 1.2 ppm, and the average of all tap samples taken throughout the entire distribution system is 0.9 ppm with a maximum of 1.2 ppm.

As the concentration in the distribution system follows that of the plant effluent so closely, there is no reason to

TABLE 6

Persistence of Fluoride in Distribution System, February 1957, Baltimore, Md.

Day of Month	Hydrofluosilicic Acid Applied* *ppm*	F^- in Plant Effluent *ppm*	Fluoride Residual at Sampling Points—*ppm*						
			1	2	3	4	5	6	7
1	5.13	1.2							
2	5.49	1.1							
3	5.13	1.0							
4	5.72	1.0	1.2	1.2	1.0	1.1	1.2	1.0	0.8
5	5.87	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.8
6	5.48	1.1	0.8	1.1	1.0	0.8	0.9	0.8	1.0
7	5.15	1.0	1.0	0.9	1.0	1.0	0.8	0.8	
8	5.65	1.0							
9	5.88	1.0							
10	5.68	1.1							
11	5.36	1.1	1.0	1.0	1.0	0.9	0.9	1.0	0.9
12	5.19	1.1	1.0	1.0	1.0	1.0	1.0	0.9	0.9
13	5.36	1.0	0.9	1.0	0.8	0.9	1.0	0.9	0.8
14	5.15	1.0	1.0	1.0	0.9	0.9	0.9	0.8	
15	5.56	1.0							
16	5.78	1.0							
17	5.73	1.0							
18	6.00	1.0	1.2	1.2	1.1	1.2	1.0	0.9	1.0
19	5.70	1.0	1.1	1.0	1.0	1.0	1.0	1.0	0.9
20	5.97	1.0	0.9	1.0	0.9	0.9	0.9	0.9	0.8
21	6.06	1.0	1.0	1.0	0.9	0.9	0.9	0.9	
22	6.13	1.1							
23	6.05	1.1							
24	5.94	1.1							
25	5.84	1.0	1.0	1.0	1.1	1.0	1.0	1.1	1.0
26	5.72	1.0	1.0	1.0	1.1	1.0	0.7	1.0	1.0
27	5.98	1.0	1.0	1.0	0.9	1.0	1.0	0.9	0.9
28	5.04	1.0	0.9	0.9	0.9	0.9	0.9	0.9	
Average	5.60	1.03							

* Strength of 23 per cent.

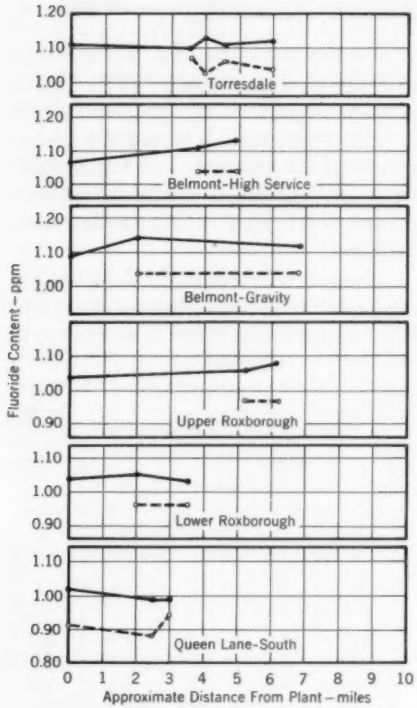

Fig. 7. Averages of Persistence Tests for 1956, at Philadelphia

Circles indicate various sampling points. Solid lines indicate Water Department results; dashes indicate Health and Water departments' combined results.

believe that fluorides are taken out of solution and stored during low flows to be later released when the velocity in the main is increased.

Table 6 gives statistical data on fluoride persistence for February 1957, which is representative of the entire period from January 1953 to the present.

Elwood L. Bean

To check on the possibility of precipitation in the Philadelphia distribution system, charts have been drawn (Fig. 7–8) showing the results of testing at various points. These are constructed to show relation of fluoride content to approximate distance from the plant in "pipe miles," which were determined by scaling a pipe map over the probable course of flow through the distribution piping.

The curves for 1956 (Fig. 7) shows the average of Water Department laboratory tests made regularly at all points. Also shown are curves for the average of all tests made by the Health Department and the Water Department

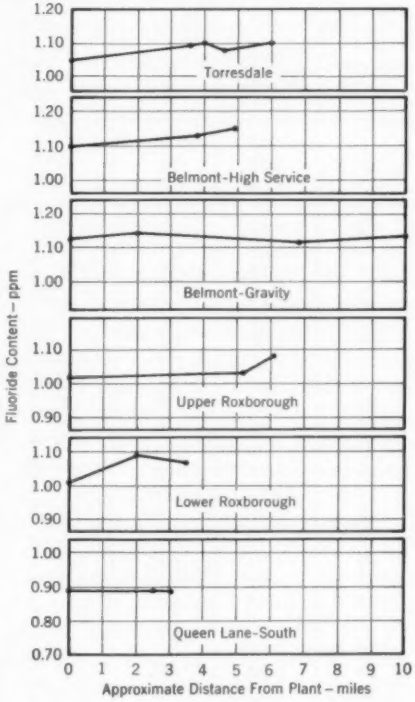

Fig. 8. Averages of Persistence Tests, January–April 1957, at Philadelphia

Results of Water Department tests are plotted, with circles indicating various sampling points.

laboratories. Figure 8, covering January to April 1957 shows curves for the average of Water Department tests in these four months. Plottings for 1955, not shown, are more erratic but the indications are similar.

It will be noted that nowhere on these plottings of averages is there any appreciable reduction of fluoride with distance from the plant, the maximum reduction shown between plant and the most distant point being only 0.03 ppm. In addition, in nine out of twelve average plottings, some increase in distribution has been indicated by the tests. The reason for this is not now known. It should be noted that each of the plant effluent results are the average of several hundred tests, a great many more than on distribution points. Finally the plottings for 1956 (Fig. 7) showing averages of all tests by the Water Department and the Health Department, identical figures are shown for points on four of the six individual systems.

The only possible conclusion from these test results is that there is no appreciable precipitation of fluoride in distribution.

James E. Kerslake

About 1,000 samples a year are taken from the Milwaukee treatment plant and another 1,000 from the distribution system at eleven widely separated points. The plant effluent samples taken from the store shaft are collected anywhere from a ½ to 2 hr after application. The samples are taken three times a day, once on each shift, without any relation to what the machine is feeding. Results show 0.2 ppm and higher, depending on what the machine is feeding at the moment. The Scott-Sanchis method is used for analysis, and results are checked by both the city and state health department laboratories. A 5-year summary of results is shown in Table 7.

Very close agreement is obtained on the averages; they are within 0.1 ppm. The individual samples run anywhere from zero up to a maximum of 1.5 ppm,

TABLE 7

Summary of Fluoride Analyses at Milwaukee *

Year	Dosage—*lb/mil gal*			Fluorides—*ppm*							
				Plant Effluent				Distribution System			
	Max	Min	Avg	No. Samples	Max	Min	Avg	No. Samples	Max	Min	Avg
1953	13.5	10.0	12.4	457	1.50	0.35	0.95	410	1.50	0.20	0.95
1954	16.2	8.7	11.8	1,095	1.40	0.40	0.97	1,010	1.50	0.40	0.97
1955	13.5	8.2	10.6	1,066	1.35	0.25	0.86	1,010	1.40	0.30	0.85
1956	12.8	7.8	10.7	1,071	1.40	0.50	0.88	996	1.30	0.40	0.88
1953–56	16.2	7.8	11.4	3,689	1.50	0.25	0.92	3,426	1.50	0.20	0.91

* Fluoridation began in July, 1953, with sodium silicofluoride used. Raw lake water contains 0.09-ppm fluoride. Since 1955 dose has been cut from 12 to 9 lb per million gallon on recommendation of the City Health Commissioner from July 4 to Labor Day. No fluoride was applied for 8 hours in 1954 (installation of circuit breaker); 10 days in August 1955 (supplier ran out of material), or 5 days in November, 1956 (strike at supplier's plant). Dose was cut from 12 to 9 lb per million gallon during the strike in 1956 to conserve supply. Application is stopped 10–15 min each week for flushing when changing machines. Samples are taken from 11 widely separated points on the distribution system.

both on the distribution system and the plant effluent. Results from the eleven sampling points on approximately 1,350 miles of pipe in the distribution system, indicate no fluoride build-up, which is the primary concern. If there were a buildup, the maximum on the distribution system would exceed the maximum at the plant.

Benjamin C. Nesin

The broader aspects of investigation in New York City indicate that the subject matter to which this discussion is limited constitutes but a minor aspect of the fluoridation controversy. The question of possible and potential hazards to health arising from the life-long imposition of an extraordinary and indiscriminate ingestion of fluoride upon whole populations is still the overriding issue which remains to be resolved (*1*).

A confrontation of the facts reveals that precise and accurate addition and maintenance of fluoride in the water supply is no assurance that the ingestion of this substance will occur with uniformity, since the amount of fluoride intake is governed by the widely varying amounts of water consumed by individuals (*2*). In this respect a group of physicians and scientists (*1*) made it clear that, "The amounts of water habitually consumed by different individuals differ greatly, and cannot be predicted or controlled. It follows that the effects of fluoridation cannot be predicted or controlled by regulation of the concentration in the water."

In general the erratic ingestion of fluoride by individuals due to this factor would ordinarily exceed anything anticipated by way of error in treatment plant control. The occurrence of error and failure in the management of fluoridation, however, further compounds any errors already inherent to its practice.

Variation and Persistence

The matter of variation and persistence of fluoride in the distribution system was first brought to attention by Feltman (*3*) of Passaic, N.J. In the course of his investigations he found that the Morristown, N.J., fluoridated supply was providing considerably less than the 1.2 ppm anticipated. On a number of occasions samples collected by him revealed fluoride values between 0.0 and 0.4 ppm. This was one of the factors which ultimately led to the discontinuance of fluoridation in Morristown after about 6 years of treatment.

In 1955, Gidley and Millar (*4*) reporting on 18 fluoridation installations in West Virginia noted that the variation in fluoride concentation ran the range of 0.2–1.6 ppm. It is also noteworthy that almost 10 per cent of the samples related to this study were not analyzed because they could not qualify for accurate determination. Although the authors regarded values between 0.8 and 1.3 ppm as tolerable, 14 per cent of the samples ran either too high or too low, despite the wide range allowed.

Many situations related to the subject of variation and persistence of fluoride have been brought to attention from almost every area of this country. Obviously, it has not been possible to investigate all of these. By way of example, several of the situations examined with some degree of directness are presented. The author advisedly refrains from naming the specific communities involved.

Situation A: This relates to a county water supply system in New Jersey serving a number of communities. In a random sampling of distribution systems in six of the communities, two showed only 35 per cent and 27 per cent respectively, of the dosage applied at the treatment plant.

Situation B: In this New Jersey community random sampling indicated approximately 65 per cent of the applied dosage in the distribution system.

Situation C: This refers to a Pennsylvania city where a random survey indicated residual fluoride in the distribution system which ran between 71 and 84 per cent of the applied dosage.

Situation D: An extensive sampling study in a New Mexico city, over a 6-month period, revealed a highly erratic pattern. Fluoride values ranged from 0.0 to 3.2 ppm, when they should have been 0.8, plus or minus 0.1 ppm. Four fixed sampling points were utilized in this study. One point showed consistently high and varied widely. The average fluoride content was 160 per cent of the specified dosage. Another sample point averaged 145 per cent of the required value. Only one of the points exhibited a mean consonant with the requirements of control, but even here the plus or minus variation left much to be desired.

Situation E: This relates to the examination of operational data of an Illinois city, for a midwinter month, when the optimal dosage should have been 1.2 ppm. Not one of the control sample points showed 1.2 ppm. The fluoride content in the distribution system ranged from 0.2 to 1.0 ppm. Only 14.6 per cent of the samples revealed 1 ppm, plus or minus 0.05. Forty-three per cent of the samples contained 0.7 ppm or less, and 23 per cent had 0.55 ppm or less.

Situation F: This relates to a city in Florida which also serves water supply to a number of communities. A survey related to the distribution system in these various communities revealed a range of fluoride residuals between 0.75 and 1.1 ppm. An examination of information related to one of the plants serving these communities revealed that it was out of operation completely for a 3-month period due to inoperative feeding equipment, and for similar reasons did not function intermittently during 3 monthly periods, in the past year. These communities have had fluoridated water for 5 years. It is obvious in this situation that they are confronted not only with errors related to control but those also attributable to outage of equipment. From reports this occurs often enough to require evaluation.

Limitations to Control

Sufficient evidence has been presented, by way of example, to show that there are definite limitations to the control of fluoride in public water supplies. In this respect averages are likely to be deceptive since the intimacies of the distribution system may reveal a different situation. However, it is clear that rigorous control of fluoride at ± 0.1 ppm or even less as has been anticipated in order to avoid toxic manifestations (*5*) cannot be entertained.

Many reasons have been offered for discrepancies from the objectives of control. Common among these are erratic operation or failure of feeding equipment, shortage of chemical supply, conservative feeding due to anxiety to avoid overdosing, problems related to multiple sources of supply, unanticipated changes in water quality, and many others. To these may be added

factors concerning which little is known, such as the capacity of fluoride to enter into complex compound formation with numerous elements, surface reaction and absorption within mains, errors due to interference, and faulty analytical procedures. Whatever the reasons may be, they are factors which affect the reliability of control.

The possibility that fluoride will settle out or become absorbed in some manner in the distribution system has been brought to the attention of laboratory personnel who have analyzed a few specimens of sediments from fluoridated water supplies which yielded between 400 and 600 ppm. There have been various reports concerning such analyses, and one laboratory reported finding 1,600 ppm in a sediment specimen. Efforts to deduce the potentiality of such phenomena, however, from relationships between treatment dosage and distribution residual have not met much success because of the relatively large operational error which attends the practice of fluoridation. The possibility of fluoride fallout in the distribution system may prove very significant in New York City even if only 0.1 ppm were involved. This would be equivalent to approximately 1,000 lb of fluoride ion daily, the fate of which demands serious interest and attention. From the data gathered, it has been observed that a dropout of 0.1–0.3 ppm may be quite common, although some situations have indicated greater reductions over the applied dosage.

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A. P. Black

With respect to the persistence of added fluoride in distribution systems, notice should be taken of the experience of the nineteen Florida towns and cities now carrying on fluoridation programs. These include Florida's largest city, Miami, and two cities of major size, Orlando and St. Petersburg. In addition, experience at Gainesville extends over a period of eight years, since fluoridation was begun in that city in 1949.

A questionnaire was addressed to the water superintendent of each city, requesting information with respect to any difficulties of any type which might have been experienced and inquiring specifically with respect to observed discrepancies between fluoride fed and fluoride accounted for in the distribution system. The city of Miami reported that some mechanical trouble had been experienced due to lumping of sodium silicofluoride in the hoppers. This has been corrected by reducing the amount stored in the hoppers. The city of Cocoa reported that the fluoride residual in the distribution system has been observed to be 0.05 ppm less than the calculated residual based upon feed. Incrustation of the influent line from the feeder has also been experienced, but the difficulty is described as a minor one requiring only a few minutes every 3–4 months to clean. No other difficulties of any type were reported. The

state sanitary engineer replied that no problems have been encountered in initiating fluoridation programs in Florida.

Solution Reduction

There is a possibility that a fluoridation chemical added to a public water supply may be reduced in amount and fail, in part, to reach the consumer for whom it is intended. Actually, there are at least three possible ways by which this might come about.

The first possibility is incrustation of the solution feed line, one example of which has already been cited. This is, of course, a very minor item and may be eliminated either by cleaning of the line as required or, as is done at Gainesville, Fla., by supplying water of zero hardness to the feeder.

The second method is through removal of the fluoride ion by the method of treatment being used. It has been shown that reduction in fluoride ion concentration results when softening waters contain magnesium (*1, 2*), and this method is being successfully employed at Bloomdale, Ohio (*2*). Concentration of fluoride ion may be somewhat reduced by coagulation with aluminum sulfate, either alone or in conjunction with a coagulant aid (*3*). Neither effect, however, need interfere with a fluoridation program since it is only necessary to add the fluoridation chemical following chemical treatment.

The third possibility is removal of the fluoride ion by some type of incrustation or coating in the distribution system. It is theoretically possible for iron tubercles to remove a certain amount of the fluoride ion from water. The tendency of the fluoride ion to form slightly ionized complexes with the ferric ion may be involved. Further, it is equally possible theoretically for deposits of aluminum oxide or incrustations containing considerable amounts of aluminum oxide to remove fluoride ion from the water. Plants are now in operation at Bartlett, Tex., and Britton, S.D., in which high fluoride ion concentrations are being reduced to acceptable values by activated aluminum oxide, and research on the method is going on in the laboratories at the University of Florida. The method probably involves ion exchange and, just as is the case with other anion and cation exchangers, regeneration must be employed after the exchange capacity of the material has been reached. Removal of the fluoride ion by incrustation present in the distribution system should behave in a similar manner and in the case of old incrustations equilibrium should be reached after which no further fluoride should be removed. In those cases where active corrosion is taking place or incrustations are building up, proportionate removal of fluoride might presumably continue as long as such conditions are present.

This process, if and when it is observed, stabilizes the system just as the water which passes through stabilizes it. The plating-out of a thin coating of calcium carbonate to prevent corrosion is a practice which has been followed for many years.

There are two obvious solutions to this problem. One would be purposely to allow the fluoride ion concentration of the water which reaches the consumer to be somewhat less than the desired figure until the stabilization process has been completed. The other would be to evaluate the effect when present and increase the feed by that amount with careful analytical control.

The important thing to remember is that one does not halt a great preven-

tive public health program because of minor technical difficulties. Fluoridation has presented the water works industry with a challenge—another in a long series of challenges which have presented themselves in applying new advances to practice. As it has done so many times before, the industry and its people have met that challenge immediately, efficiently, and completely.

Indianapolis to maintain approximately 1 ppm fluoride residual in the plant effluent. Since 1951 samples have been collected daily from each of the plant effluents and from widely spread points in the distribution system. Tables 8 and 9 summarize the 1952 figures on residuals.

The totals of samples on the White River system in 1952 were: 254 samples of plant effluent; 244 samples from Washington Station, a secondary pumping station; and 84 samples each from booster pumping stations in the extreme south and the extreme west parts of the city (Table 8).

TABLE 8

White River System Fluoride Residuals, 1952, Indianapolis, Ind.

Month	Filter Plant Effluent		Wash. Pumping Station, 3.1 mi From Plant		Ben Davis W. Booster Station, 4.3 mi From Plant		S. Booster Station, 6.5 mi From Plant	
	No. of Samples	Avg. Res. *ppm*	No. of Samples	Avg. Res. *ppm*	No. of Samples	Avg. Res. *ppm*	No. of Samples	Avg. Res. *ppm*
January	22	1.11	23	1.05	7	1.02	7	1.01
February	21	1.05	21	1.04	7	1.00	7	0.98
March	21	1.00	21	0.97	7	0.95	7	0.95
April	22	0.98	21	0.98	7	0.90	7	0.91
May	21	1.00	21	0.96	7	0.94	7	0.95
June	21	1.00	21	0.91	7	0.94	7	0.94
July	22	0.97	22	0.95	8	0.90	8	0.91
August	21	0.96	20	0.97	7	0.92	7	0.91
September	21	0.92	14	0.92	6	0.93	6	0.92
October	23	1.07	19	1.01	7	0.97	7	0.95
November	18	1.00	19	1.02	7	1.01	7	1.01
December	21	1.10	22	1.03	7	1.00	7	1.00
Total	254		244		84		84	
Avg Res.		1.01		0.99		0.95		0.95

References

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Marshall P. Crabill

Sodium silicofluoride is applied at each of the two treatment plants in

The Fall Creek plant in 1952 totaled 255 plant effluent samples plus 252 from a laboratory tap on the high-pressure system and 82, 85, and 84 respectively from two elevated tanks and a booster station in the extreme east section of the city (Table 9).

White River Residuals

The range of residuals in the plant effluent from the White River system on the basis of a monthly average varied in 1952 between a maximum 1.11-ppm residual obtained in January to a minimum of 0.92 ppm obtained in September. The plant effluent samples are collected from the chlorination basin outflow as the water leaves the plant to flow about 1.25 miles to the Riverside Pumping Station (Fig. 9). From the Riverside Pumping Station a portion of the water flows by gravity from the clear well to a secondary pumping station another 1.9 miles distant. At this location, the Washington Pumping Station, the maximum monthly average for 1952 residual fluoride also occurred in January and averaged 1.05 ppm. The minimum monthly average at Washington Station was 0.91 ppm, occurring in July when the treatment plant effluent averaged 1.00 ppm. In September, when the treatment plant effluent averaged 0.92 ppm, Washington Station also averaged 0.92 ppm.

The distance between plant effluent at the White River treatment plant and the booster station in the extreme westerly part of the city is about 4.3 miles. The maximum monthly average for 1952 at the west booster station occurred in January, with a 1.02-ppm residual compared to 1.11 at the treatment plant effluent. The minimum booster residual was 0.90 ppm. The same is true of the South booster station which is 6.5 miles from the point of application at the treatment plant. The fact that the west and south booster stations have residuals which on monthly averages check within 0.01

TABLE 9

Fall Creek System Fluoride Residuals, 1952, Indianapolis, Ind.

Month	Filter Plant Effluent		Laboratory Tap		Irv. Tank, 6.7 mi from Plant		Blue Ridge Tank, 2.7 mi from Plant		E. Booster Station, 4.2 mi from Plant	
	No. of Samples	Avg. Res. *ppm*	No. of Samples	Avg. Res. *ppm*	No. of Samples	Avg. Res. *ppm*	No. of Samples	Avg. Res. *ppm*	No. of Samples	Avg. Res. *ppm*
January	22	1.06	22	1.04	7	1.05	8	0.98	7	1.03
February	21	0.98	21	0.99	7	0.99	7	0.98	7	0.99
March	21	0.99	21	0.99	7	1.00	7	0.99	7	1.00
April	21	1.00	21	0.97	5	0.94	7	0.96	7	0.91
May	21	0.81	20	0.82	8	0.84	8	0.85	7	0.81
June	21	0.87	21	0.90	7	0.80	7	0.84	7	0.89
July	22	0.92	22	0.92	7	0.85	6	0.88	7	0.86
August	21	0.89	21	0.94	7	0.91	6	0.95	7	0.89
September	21	0.90	21	0.89	7	0.89	7	0.90	7	0.86
October	23	0.93	23	0.94	8	0.94	8	0.92	8	0.96
November	19	0.91	19	0.92	5	0.91	6	0.92	6	0.88
December	22	0.88	20	0.90	7	0.89	8	0.93	7	0.91
Total	255		252		82		85		84	
Avg Res.		0.93		0.93		0.92		0.93		0.92

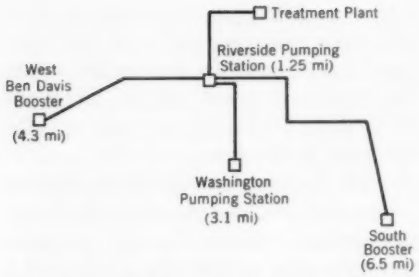

Fig. 9. Diagram of White River System, Indianapolis, Ind.

Locations of pumping and booster stations are indicated, with approximate distances from main plant effluent.

ppm for 10 months of the year and 0.02 ppm the other 2 months indicates that they are essentially identical. In the case of the west booster station the water has traveled no less than 3.1 miles from the primary pumping station and the south station water has traveled no less than 5.4 miles from the primary pumping station. (Reference to Table 10 will demonstrate that the results in the other 4 years appear to be much the same as in 1952.)

Fall Creek Residuals

Similarly, the 1952 results and the Fall Creek treatment show a maximum monthly average fluoride residual of 1.06 ppm in January and a minimum of 0.81 ppm in April. These results were for the plant effluent on the basis of 255 samples for the year. Fluorides are not determined on Saturday and Sunday samples. A total of 252 laboratory tap samples, from the high pressure pumps on the adjacent pumping station, indicate a maximum monthly average of 1.04 ppm in January and a minimum of 0.82 ppm in April. Table 11 shows 5-year averages for the Fall Creek system.

The Irvington elevated tank on the Fall Creek system is 6.7 miles distant from the pumping station (Fig. 10) and indicates a maximum monthly average fluoride residual in January 1952 of 1.05 ppm, as compared with 1.06 ppm in the plant effluent and 1.04 ppm in the laboratory tap. Another elevated tank, 2.7 miles distant from the pumping station in an opposite direction from the Irvington tank, re-

TABLE 10

Five-Year Summary of Fluoride Residuals, White River System

Year	Filter Plant Effluent		Wash. Pumping Station, 3.1 mi From Plant		Ben Davis W. Booster Station, 4.3 mi From Plant		S. Booster Station, 6.5 mi From Plant	
	No. of Samples	Avg. Res. *ppm*	No. of Samples	Avg. Res. *ppm*	No. of Samples	Avg. Res. *ppm*	No. of Samples	Avg. Res. *ppm*
1952	254	1.01	244	0.99	84	0.95	84	0.95
1953	237	0.95	155	0.92	80	0.89	79	0.89
1954	211	0.97	151	0.92	70	0.89	71	0.88
1955	167	0.94	133	0.94	49	0.90	47	0.87
1956	233	0.99	161	0.98	77	0.97	78	0.96
Total	1102		844		360		359	
5-yr Avg Res.		0.97		0.95		0.92		0.91

TABLE 11

Five-Year Summary of Fluoride Residuals, Fall Creek System

Year	Filter Plant Effluent		Laboratory Tap		Irv. Tank, 6.7 mi from Plant		Blue Ridge Tank, 2.7 mi From Plant		E. Booster Station, 4.2 mi From Plant	
	No. of Samples	Avg. Res. *ppm*	No. of Samples	Avg. Res. *ppm*	No. of Samples	Avg. Res. *ppm*	No. of Samples	Avg. Res. *ppm*	No. of Samples	Avg. Res. *ppm*
1952	255	0.93	252	0.93	82	0.92	85	0.93	84	0.92
1953	252	0.86	252	0.86	81	0.84	85	0.84	79	0.84
1954	253	0.89	255	0.89	82	0.88	83	0.85	83	0.87
1955	242	0.90	244	0.89	77	0.88	76	0.87	81	0.88
1956	247	0.94	249	0.94	82	0.92	80	0.91	82	0.91
Total 5-yr Avg Res.	1249	0.90	1252	0.90	404	0.89	409	0.88	409	0.88

cords a January monthly average of 0.98 ppm and a minimum monthly average of 0.84 ppm. The elevated tank residuals are particularly impressive since the tanks are not completely emptied during any one day or week. Residuals from the plant, if they varied through a wide range, should reflect wider differences between the tank and plant residuals. Since they are regularly uniform, the fact that the application at the plant is easily and accurately controlled is well established. All residuals were determined by the Scott-Sanchis Method.

In late April and the first few days of May 1957, fluorides have been determined on about 45 samples collected from dead-end mains. The residuals in these samples appear to average about 0.1 ppm less than is recovered at the active stations in the system. This small number of samples is not sufficient to draw any conclusions at this time, but the study is expected to continue.

Fluoride residuals in the Indianapolis system are checked periodically by the Indiana State Board of Health laboratory. At such times, samples are collected in duplicate and a sample from the same source run in the water company laboratory and the board of health laboratory. For several years the results on the samples have been identical. A portion of the samples in the board of health laboratory were also run by distillation, with similar results.

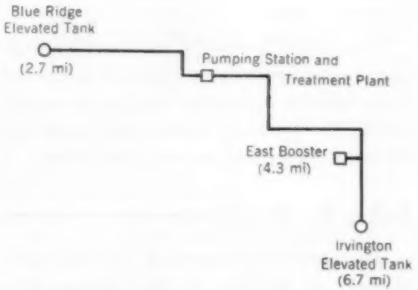

Fig. 10. Diagram of Fall Creek System, Indianapolis, Ind.

Locations of booster station and tanks are shown, with approximate distances from the main pumping station.

Robert S. Phillips

Since the beginning of the Charlotte, N.C., program in 1949, daily fluoride determinations have been made on the untreated and treated water at the purification plant. In addition, 20 pooled samples per month are collected and analyzed from widely scattered points throughout the distribution system. There is no evidence which would show that there is a significant buildup or loss of fluoride in the distribution system. Table 12 shows the results obtained.

TABLE 12

Yearly Averages of Fluoride Concentrations, Charlotte, N.C.

Year	Untreated Water *ppm*	Treated Water *ppm*	Distribution System *ppm*
1950	0.05	0.87	0.86
1951	0.05	0.84	0.83
1952	0.05	0.86	0.86
1953	0.05	0.87	0.87
1954	0.05	1.00	0.99
1955	0.05	0.99	0.98
1956	0.05	0.91	0.90
7-yr avg	0.05	0.91	0.90

The fluoride results on the distribution system represent samples collected from widely separated but active points within the system. Dead-end sampling stations, however, are not included.

John R. Baylis

To obtain information on the persistence of fluoride in the Chicago distribution system, samples from the extremities of the south district distribution system were recently collected and tested for residual fluoride. The amounts found in the samples are almost exactly the same as the amount applied plus that naturally in the water. The conclusion is that the loss of fluoride by being absorbed in iron tubercles is an amount so small it cannot be distinguished by chemical tests. The fluoride in the Chicago water does reach all locations on the distribution system in the amount applied.

Tubercles from the Chicago water system were analyzed to determine the concentration of fluoride ions that might be present after contact with water containing 1.0 ppm fluoride for a period of 1 year. Table 13 shows the results of extraction tests on the collection of tubercles. These were broken up and placed in a flask with 500 ml fluoride-free distilled water, allowed to stand from 1 to 7 days with occasional shaking, after which 450 ml of clear solution was withdrawn for each test. Results are based on grams of material extracted per 100 g of tubercles. Analyses were made by spectrophotometer.

As will be noted from the tests, some fluoride is present in the tubercles, but the extraction rate is so slow that the fluoride dissolved from a number of broken tubercles in a water pipe would be negligible. The author cannot see how an injurious amount of fluoride could be present in the water in the main containing a number of broken tubercles, as the dilution factor would be very high even under low-flow conditions.

The following conclusions may be made regarding distribution of fluorides in a water main network.

1. In a water system, where the rate of flow of water is known at some given point, fluorides can be added to the water in the exact amount desired.

2. The fluoride added will extend to the extremities of the distribution system, with no measurable lessening

of the concentration in the water flowing in the mains.

3. Fluoride ions may concentrate in tubercles in small amounts, together with other negative ions in the water such as SO_4 and Cl. This separation of negative and positive ions is electrochemical in nature and is necessary for the promotion of tubercles.

4. The rate of concentration of these materials is so slow that the amount of fluoride removed from the water cannot be measured by the usual test methods.

5. There is no way in which the fluoride concentrated in the tubercles can be remixed with the water so as to bring about a measurable increase in fluoride content of the water flowing in the pipe.

6. Iron rust loosely deposited in water pipes outside of the tubercles will not absorb a measurable amount of fluoride within the rust particles. Thus, when brought into suspension as a result of high flow rate, they will not measurably increase the concentration of fluoride in the flowing water.

7. There is no way in which part of a water system, such as house services, can be operated so as to bring undue amounts of fluoride to a consumer.

8. Tubercles cling tightly to iron

TABLE 13

Extraction of Soluble Materials From Tubercles, Chicago

Date 1957	Days Standing	Solution Withdrawn *ml*	pH	Calcium *g*	Fluoride *g*	Chloride *g*	Sulfate *g*
			Sample 1*				
4/23	1	445	7.80	0.007	0.0001	0.016	0.045
4/25	3	450	7.68	0.012	0.0002	0.000	0.026
4/29	3	450	7.41	0.006	0.0002	0.000	0.014
5/3	4	450	7.59	0.004	0.0006	0.000	0.018
5/6	3	450	7.40	0.006	0.0002	0.000	0.009
5/13	7	450	7.13	0.006	0.0001	0.000	0.013
5/20	7	450	7.62	0.005	0.0002	0.000	0.014
5/27	7	450	7.47	0.005	0.0002	0.000	0.012
Total				0.051	0.0018	0.016	0.151
			Sample 2†				
4/23	1	450	8.03	0.004	0.0005	0.000	0.040
4/26	3	450	7.68	0.017	0.0009	0.000	0.031
4/29	3	450	7.30	0.008	0.0006	0.000	0.020
5/3	4	450	7.55	0.021	0.0006	0.000	0.026
5/6	3	450	7.39	0.011	0.0006	0.000	0.023
5/13	7	450	7.60	0.014	0.0009	0.000	0.033
5/20	7	450	7.62	0.012	0.0009	0.000	0.032
5/27	7	450	7.48	0.008	0.0008	0.000	0.030
Total				0.095	0.0058	0.000	0.235

* Sample 1 consisted of 96.4 g of tubercles from iron pipe in a settling basin.
† Sample 2 consisted of 3.80 g of tubercles from a 36-in. tee in a filtered-water line.

pipe and flushing, regardless of how violent, cannot dislodge an appreciable amount of tubercles. (It would be quite helpful to operators of systems handling corrosive water if tubercles could be removed by flushing.)

9. Fully 99 per cent of the consumers served by a water system will receive water containing the full amount of fluoride added. The remaining 1 per cent may receive water with a slightly lesser amount than that added.

10. No water system should consider discontinuing fluoridation because of fear that abnormal concentration of fluorides will occur in any part of the system.

These comments are not to be taken as advocating fluoridation of water as a public policy. They are based upon a professional lifetime of study of the corrosion of water pipe and are intended to correct certain misinterpretations of the facts.

Revised Cast-Iron Pipe Manual Available

A revised and expanded edition of the American Standard Practice Manual for the Computation of Strength and Thickness of Cast Iron Pipe—ASA A21.1–1957 (AWWA C101–57) is now available. The new edition consists of three parts—an explanation of principles and methods; thickness tables for pit-cast and centrifugally cast pipe for water; and similar tables for gas. The 172-page manual is priced at $1.50 per copy and may be obtained from Order Dept., American Water Works Assn., 2 Park Ave., New York 16, N.Y.

Problems in Personnel Recruiting

Milton Rosen

A paper presented on May 16, 1957, at the Annual Conference, Atlantic City, N.J., by Milton Rosen, Comr., Dept. of Public Utilities, and Pres., Board of Water Comrs., St. Paul, Minn.

WATER supply is the most important problem confronting any city today. People who know say that America may be running out of water, and this is no joking matter. The rivers and lakes—almost without exception—are contaminated by human waste and dangerous industrial wastes. Underground resources are being depleted. It is said that underground levels of the water tables in most of the nation are falling steadily.

Water is America's No. 1 problem—yet too few young men are willing to cast their futures in the water works field, largely because of inadequate compensation and because this problem has not been given the proper consideration by public officials or by the public at large.

In many years as a member of the St. Paul City Council—assigned to the Department of Public Works, Public Utilities and Finance—the author has had the opportunity and the need to observe some of the personnel difficulties which confront all municipal and—in the same manner and to somewhat the same degree—state and federal governmental units. To a considerable degree, those in public employment are the victims of their own actions. As taxpayers they penalize their own best interests when they demand the best of public service and at the same time impose restrictive measures which so often defeat the employment of capable technicians, engineers, and management—men who have the qualifications to serve their purposes.

More and more, private industry is engaged in the search for potentially capable engineers and technicians. To obtain them, the graduating classes of colleges and universities are being screened and recruited every year. While governmental units are not, and today cannot, meet this type of competition, they are losing out in the race for good help. That is not to imply that there is not now a legion of loyal and eminently capable men and women in public service—personnel who have placed love of a job ahead of any other consideration. But the big personnel problem faced in public service today is not alone to hold the present line, but also to prepare for future demands—to be able to make capable replacements when necessary and to meet the growing demands for expanded services in the industry, which can be no stronger than the men and women employed. Certainly, then, the recruiting of good personnel is of prime importance to all water works administrators.

To answer the question of whether there is a problem, administrators have only to appreciate the fact that in competition with industry in general and with private utilities in particular, the

water works industry runs a bad second, both in attracting good and sufficient help and in training such help as is obtained.

Reasons for Problem

Why is this so? Ranking high on the list of reasons is the lack of proper and adequate compensation, followed closely by antiquated ideas and regulations which retard recognition of leadership and competency. When times are bad and there is a depression, when private employment is at a low ebb, municipal jobs become attractive only because the wage of public employment, while low, stands reasonably stable, while private wage scales follow more closely the laws of supply and demand. During periods of prosperity the reverse condition prevails, and the capable help that public service has picked up leaves. Security in employment is certainly a splendid thing for all concerned, but security is not attractive at low rates of pay. The public has for many years been imbued with the idea that employees on a public payroll are paid enough or too much, completely losing sight of the need for competent help in public service as well in private industry.

In addition, the theory that certain fringe benefits given public employees are not made available to employees of private industry is outmoded. Surely, it must now be realized that private industry has almost universally matched, and in many instances today has even gone beyond, public employers in this respect. Large companies provide for and carry life insurance policies for their employees; they also provide every form of recreational benefit, high retirement pay, sick and vacation benefits, and in many instances, bonuses.

There are many good qualities and benefits in civil service regulations. Many of the rules may be rules of necessity, but in just as many cases they are deterrents to the best and most efficient administration of public affairs. This may be entirely contrary to the rather common and generally accepted theory of equal pay for like work, but as applied to the highly technical help, it is not a proper criterion.

The experiences with which the author is acquainted in St. Paul must be typical of all cities. In St. Paul, the utility acquires, or attempts to acquire, its personnel through written civil service examinations. Those who pass are placed on probation for a period of 6 months, during which time they may be dismissed from service without preferring any charges. This is to be a good and proper method of weeding out those who fail to measure up to the standard of a good employee. But what is the result? Few people employed elsewhere, even if ambitious and seeking advancement, will gamble on a change which is subject to written examination and the risk of losing the new job after or during a short probationary period.

One of the difficulties of the civil service system in its application to wage control is its lack of flexibility—its inability or unwillingness to adjust the wage scales to meet changing economic conditions. It lacks the ability to move quickly in this respect. Even a wage classification which is automatically adjusted annually to a cost-of-living index is often a year behind.

Too often and too generally the spread between the lower classifications in municipal employment and the higher or top jobs is entirely too small. Personnel problems of today, particularly in reference to the technical employees, are not so much related to the abilities of employees as they are to lack of sufficient help. There is more

work for public utilities, but the productive output is lagging. The known needs for enlargements—for building against the needs of the future—are being delayed too long. The days of the future are too soon the todays, and utilities are unprepared because they lack in numbers the men with vision and accomplishment. What steps are being taken to train young men for higher and responsible jobs? Some cities have met the problem by farming out much of their engineering work to consultants who can and do pay the going required wage to attract the kind of help needed. Some are returning to service old employees in retirement. Old employees die, however, and they will continue to retire. At best these actions are but stopgaps to a final solution.

Need for Action

As goals have been set for better and more adequate systems to meet the increasing demands for water, the need for more and highly trained personnel is increasing. The present expanded highway program for the entire United States, the creation of large housing authorities, and the replacement of slum areas have and will continue for years ahead to place an obligation upon water systems to meet these changing conditions with extended water distribution facilities. The rapid growth of suburban areas, many demanding services from existing utilities or newly created water districts, are further contributing factors which demand enlarged facilities from sources of supply to ultimate delivery to the consumer. This creates a greater need for more technical help.

As public utilities search the field for technical assistance they are competing with private utilities and industry—competition armed with the ability to meet their needs with apparently unlimited funds. Each year the inducements to new graduates have increased. It is sad to have to admit that public utilities are not holding their own in this competition for the technical help that must be found if they are to meet the challenge of keeping pace with fast-growing economy. To keep pace with the need for trained technicians, industry every day is flooding the newspapers with desperate pleas for help.

High school students cannot be regimented to train for engineering careers, but there is a responsibility to see that all students receive compulsory training in mathematics and the basic sciences. Interests must be discovered or created in those who have the ability or latent talent, if the shortage in trained scientists and engineers is to be overcome. At the College of St. Thomas, in St. Paul, approximately 20,000 high school and college students were expected to attend the third annual Career Festival held several months ago. This meeting is sponsored by several colleges located in St. Paul, and they do a great deal toward helping these young people choose their life work. There were reservations from 150 schools throughout Minnesota, but when these young people came to the meeting they knew nothing about what career they wanted to follow.

The problem of solving these personnel problems is left to those in the industry. In the opinion of the author—an elected official who has a share in the responsibility of determining the wage scales in one city—the reason behind the condition is not entirely apathy on the part of elected officials. By and large they appreciate the problem. The necessary push must come from those most affected. During the past few years much has been heard about the shortage of school teachers, largely accounted for by the wage in-

ducements given them in other fields. The public is by now thoroughly familiar with this story, and certainly some beneficial gains have resulted. By news releases, by radio, by television, the story is told and retold, first by those most intimately affected, then by the parent-teacher associations, and finally by the press and those formally interested. This is mass accomplishment. This is what the American water works industry needs. Much is being done by the AWWA, but the desired end result can be realized only when the public, city officials, water works operators, engineering organizations, and technicians become not just passively sympathetic, but very vociferous.

Obtaining technicians from the present available supply is the immediate problem, but of equal importance is assurance that new blood is being trained in high schools and universities and colleges. Reports show that while an overwhelming number of the nation's youth have their hearts set on a college education, most of them are oblivious to the crying need for technicians and engineers. They fail to believe that thousands of good paying jobs for young engineers go begging for recruits each year. Too many of the high school graduates, however, do not enter college, and of those who do attempt to enter, 61.5 per cent of the applicants are turned down because of low grades and poor preparation in secondary schools. Many high school principals say the universities are too quick to reject an applicant, and many university professors say the graduates of high schools come to them very much unprepared.

Conclusions

There is no industry problem which demands more considered and continued thinking, study, and application than that of acquiring and holding the young engineers and technicians who alone can guarantee the enlargement and development of the water systems of the future. Many utilities have worked too long with too little, and should not fail to meet the challenges of the future because of the lack of either men or money. The need for water is too great to permit failure. In order to meet the problem, the following recommendations are made for water works administrators:

1. Stress the need for suppliers of water department equipment and materials to sponsor young students entering universities to study water department problems.

2. Strive to raise the salary structure of all employees in a community's most important activity—the water department.

3. Encourage more young men to become interested in the water utilities in their communities.

4. Appreciate the value of the many old and reliable employees who are an integral part of the water utility in any community. Too often there is little attention paid to them and the fine work they are doing.

Recruiting and Training of Personnel

W. A. Hardenbergh

A paper presented on Mar. 19, 1957, at the Southeastern Section Meeting, Charleston, S.C., by W. A. Hardenbergh, Editor, Public Works Magazine, *Ridgewood, N.J.*

IT is the role of the water works industry to keep water flowing to the homes of the people in American communities—water that is adequate in quantity, safe, delivered under proper pressure, and without taste, odor, color, or turbidity. To do this properly, the industry must have management ability, technical knowledge, good planning, proper personnel, adequate tools and equipment, and the support of city governments.

Over the past 10 years this job has become much more difficult. Cities have grown in area and in population, sometimes very rapidly; per capita water consumption has increased; and costs have gone up. Suddenly the safety factors originally built into water systems are inadequate. In the meantime, the water works industry has been doing a good job and saying too little about it. City governments have become accustomed to this quiet service—so much so that primary interest is often centered on traffic problems, schools, waste disposal, or other equally necessary or desirable public works.

There can be no more important community service than water supply. The problems are: [1] to train present personnel to meet growing technical requirements; [2] to utilize more fully modern equipment and methods; [3] to make the profession more attractive through improvement in pay, working conditions, and advancement opportunities; and [4] to insure a continuing flow of smart young men into the field.

There are three phases to this program. One embraces what the state can do; a second is what the community can do; the third and most important is what individual personnel can do.

State Action

The state can establish standards which will insure that recipients of operator or other certificates will have an adequate professional basis of training. This will involve examinations, for which training courses must be provided. About half of the states now have such certification programs, of which one-third operate under state laws and two-thirds are voluntary. There is no uniformity in the various requirements, even in the question of who shall be certified. For instance, some of the states license only plant operators, while others include both water system managers and operators.

The educational program to go along with the program of certification should include participation by state universities. For example, Clemson College in South Carolina has an unusually fine combination of conference-type short school and correspondence courses. Whatever is provided must include cer-

tain requirements if it is to be fully effective. These basic requirements are: [1] the instruction offered must be locally available, so that unduly long trips to attend the schools and too much encroachment on employees' leisure are avoided; [2] the programs must be truly progressive, leading from the elementary level to advanced study; and [3] good instructors must necessarily be provided. A combination of correspondence work with the short courses and with regional schools is highly desirable, as this provides for well-rounded training and an opportunity for steady advancement and can also permit credits which might ultimately be of value in obtaining a technical degree. Certification should be combined with adequate publicity and, if possible, with salary increases as an incentive.

A program for local research under the sponsorship of the state departments of health or under supervision of the short course could lead to greater interest on the part of many local operators, appreciation of their skills by the communities which employ them, and the acquisition of valuable knowledge. There are many things unknown at present about the daily operation and maintenance of a water plant and a water system. Carefully selected research projects, based on local problems or interests, could add much to knowledge of practical plant operation.

Another thing that the state can do is to aid in emergency planning. This may involve assistance and cooperation in surveying plants to determine the hazards most likely to occur and planning to be ready to meet these hazards. Civil defense is also important. Although a community may not be considered, even remotely, a target area, it can help others which are in that category. This requires study and development of a mutual aid program with nearby communities which will determine what contributions can be made and how.

Community Action

As a minimum basis the community should provide a reasonable salary. What this will be may be based on the size of the city and the number of employees supervised. If a fair pay scale for certified operators can be established, then completion of study courses and granting of licenses should bring such a scale into effect automatically. Security is another benefit the community should provide, which means that politics, or anything else but merit, should not affect a man's job. Security is improved by the licensing or certification system, since no man holding a license can be replaced except by another qualified operator.

Good working conditions are important. Every superintendent or operator should have an office equipped so that he can carry on his work efficiently, have high school and other groups in to see how the water works operates, and, in general, be proud of his place of business. He should also have the tools and equipment he needs to do his work efficiently. It has been the general history of municipalities that they are always a couple of steps behind in the utilization of labor-saving equipment. Modern power machinery can reduce costs and speed up work, both of which are necessary things today. With present traffic conditions, for instance, work must be planned so as not to block a busy street any longer than is absolutely necessary. Payoff in terms of both salary and esteem is as

likely to come from good management and administration as from technical skill.

Companionship is often an important factor, especially with new men coming into the department. The city should have an interest in these men and a policy for making them feel that they are a part of an important business. Many personnel departments in the larger cities have programs covering these factors. Some of them also have in-service training programs in which the water utility should participate. Such training may include equipment operation, safety on the job, and various phases of field or plant operation. Also, some items of plant equipment, such as chlorinators, chemical feed machines, and controls, are essential to the continuity of treatment and the safety of the supply. Teaching several employees techniques of operation, maintenance, or repair of these machines, or the utilization of substitute equipment, will pay dividends in an emergency. It will also pay dividends in upgrading the overall abilities and interest of the staff.

Individual Action

What others can do is not nearly so important or resultful as what individuals can do for themselves. Some of these things, but not all, can be grouped under three general headings: [1] improving technical skills; [2] operating and managing the plant in an efficient and orderly manner; and [3] developing leadership and assuming responsibility.

Under educational advancement, it is necessary to take advantage of all opportunities to increase technical knowledge. It is not necessary to be an engineer in order to be a good water works superintendent or plant operator. There will never be enough engineers for all these jobs, and, except in the major cities, they are not needed to fill them properly. Every water works man should belong to such appropriate technical groups as the AWWA, which has a very fine training program and an equally excellent public relations program, personalized by "Willing Water." Likewise, every water works man should get and read a reasonable number of the technical magazines serving this field. He should buy the latest editions of the relatively few water works books that are available, and he should read and study them. He should strive to get the highest grade of license that is available, and should never overlook other forms of recognition.

In running a plant, it is also important to keep it neat, clean, orderly, and attractive, both inside and out, as well as efficient. A study of its operation may show that there are factors which can be modified for more efficient operation. Personnel must be kept under good control, properly trained for the jobs they have to do and furnished with a routine to follow to insure that the various work items are performed and are properly done.

In-service training is an essential to a well-run organization. Every employee has a right to a chance to increase his professional competence. The head of each department is responsible for providing such training to those under his charge. Help can be obtained from the city personnel division, from a nearby university or from the state department of health. Basic requirements of a training program include selection of what is to be presented, who is to present it, and

how, when and where it is to be presented. Preparation involves both work and planning, but it is richly rewarding. As in other phases of in-service training, the program should not encroach on the leisure time of the employees nor require considerable travel or cost on their part.

Recruitment of personnel has two phases. One is represented by the man with special training who is needed to do a particular job or carry on a special program. To get such a man, the salary must be competitive. The other phase involves the staff additions that every activity must have if it is to continue to do a good job and grow. Mostly these are the young men who can find an attractive and rewarding field in water supply. A good place to start is in the high school, offering vacation or part-time work to some of the promising boys. If these young men later go away to engineering schools, they will be better equipped for their future work by virtue of the practical experience they have had. If they do not go to college, they may become permanent members of the staff. This is but one of the sources from which recruits can be obtained. Naturally, salary competition will have to be met just as is the case in every other field. At times, civil service may be a handicap to recruiting because of the time lag between examination and employment.

There is no man in a position as favorable as is the local water works manager or superintendent for watching and studying the growth of his community as it affects water system performance or for establishing a system of records that will provide a timely warning of future needs. Engineering skills may be necessary to evaluate properly some of these data in the light of design, but having the information available can save much time and money to the community. Stream and lake levels and rainfall records are always valuable, as are consumption data with special reference to peak hourly, daily, and monthly demand for water, not only for the community as a whole, but for the various sections of the area served. Pressure data at times of heavy consumption are useful. Information on water quality, with notes on variations in bacterial count, taste, chlorides, hardness, odor, or turbidity and possible influencing causes, should be recorded.

It is good practice to make a record of the day-to-day problems that occur and of observations relating to them. A plant or office diary, in which are recorded all events of any apparent importance, can be most valuable. Records, of course, should be complete. A map of the water system, showing valve locations and pipe sizes, is a necessity. Visiting other water plants to see what they are doing and to become familiar with their problems and methods is an excellent source of knowledge.

Checking of equipment should be a regular procedure. For example, are the pumps operating efficiently, or do they need new or different impellers because of wear or of changed operating conditions? Are the master meters recording accurately and the chemical feeders calibrated correctly? Is unaccounted-for water excessive? Is the location of all important valves known so they can be found on a stormy night? Should they be fully open or entirely closed? Will they function if needed?

Suitable power equipment is something no one can do without if his

department is to be run smoothly and economically. Therefore, another job for the water works manager, is to watch for new equipment that will do his work better, quicker and at less cost; evaluate it for local needs and conditions; and, if it is needed, see that it is purchased.

Conclusions

These various matters have been outlined, not to tell water works men a few of the details of their work, but to emphasize that the larger phases of utility operation should be seriously considered. The man who will take charge is the man who is wanted; if he can take charge efficiently, he will have less of a problem in getting paid the kind of salary he ought to have. The water works manager or superintendent should know as much about the water supply business as anyone else in the community knows about his own business. If he has this knowledge, he can take his proper place in municipal government and in civic affairs; he may expect a salary commensurate with that received by other key people employed by the city; he can ask—and expect to get—needed equipment and personnel; and he can give timely and valuable guidance to his community in regard to needs for the future.

A training program is essential, for it is one of the steps in preparation for knowing how to do the job well, though some things cannot be learned in such a program or at a school. Technical improvement can help, but individuals must develop the administrative and management skills which make the outstanding difference in those factors of salary, security, and local esteem and standing.

In-Service Training and Certification

Raymond J. Faust

A paper presented on Mar. 19, 1957, at the Southeastern Section Meeting, Charleston, S.C., by Raymond J. Faust, Exec. Asst. Secy., American Water Works Assn., New York, N.Y.

THE need for supplementing the formal education of employees by in-service training has never been greater than it is today. The present tendency in all manufacturing and service organizations is to apply automatic or semiautomatic solutions to problems and thereby eliminate or minimize manual solutions. This trend cuts down on labor costs and always provides a better and more accurate control of operations, thus resulting in a better product or a better service.

Water systems have also been affected by this trend, and with the greater application of automation to the industry, the need for more highly trained operating personnel is self-evident. The mechanical or electrical gadget is taking over at many places where the back muscle was previously supreme. To operate this automatic equipment and keep it in service requires a higher degree of skill. Thus, in-service training courses are an established part of any well operated utility. No longer is it possible to get by with a manually operated plant. The "gadget" has proved itself and can be relied upon to do a better job at a lower cost. It behooves water utility executives to recognize these trends and meet them by providing in-service training of the type required to train personnel to handle the specific equipment employed.

It should be emphasized that in-service training is not and never will be a substitute for formal education. It is strictly an adjunct to it. Thus, it is imperative that the water works executive, in obtaining his staff, select only personnel that have adequate formal education in which to build special skills with in-service training. The combination of adequate formal education and good in-service training is the key to a staff of high quality and a successful operation. One without the other is never adequate.

Development of Training

In-service training in the water industry is not new. Its start was tied in with the discovery of various relationships between water supply and public health. It will be recalled that even the first public water systems in the United States included health and fire protection as primary benefits. Although very little thought was given to the safety of the supply itself because the germ theory of disease had not yet been established, it was thought that flushing of streets to rid them of odor and filth would contribute to the health of the community. The popular belief was that disease had something to do with obnoxious odors, so to flush the offensive material away appeared logical. Although this program missed its

objective in reducing the tragic costs of the annual epidemics that plagued the people, it is interesting that public water supply should have been associated in the public mind—even indirectly—with public health at this early period.

The first public water systems in the United States were built late in the eighteenth century. These supplies were used very sparingly for drinking and domestic use. As the population of the cities grew, however, the dug wells and springs which were used for sources of drinking water became inadequate, and, as a result, greater reliance was placed on public systems for water for all purposes. Gradually, running water was piped into homes, stores, and industrial plants. Such service, of course, could be rendered only to those buildings located on streets in which a water main existed. It was not long, therefore, before the convenience of having water under pressure in the home became appreciated and resulted in a mild clamor for this type of service. To provide this service required that the system be extended to other parts of the town. Thus was started a demand for water service which has not abated to this day.

With the increased dependence on public water supplies for drinking and culinary purposes, epidemics of typhoid fever, dysentery, and cholera became more prevalent and the size of the epidemics increased. Thus, in 1875, in this almost intolerable setting, Pasteur and Koch expounded their germ theory of disease, and for the first time definite proof of the cause of the epidemics that ravaged the cities was at hand. People knew or were soon to learn that sewage-contaminated water carried bacteria that produced epidemics. Although this knowledge was fundamental, it left unanswered the question of how to safeguard the water supplies. Under these circumstances the public water supplies could not be relied upon to provide drinking water until their safety could be assured. Therefore, dependence on private sources of drinking water continued, and the epidemics continued. The sanitation of ground water sources was still in the future and had to be learned the hard way—through sickness and death.

Sanitation techniques for testing water quality were only beginning to crystallize by 1904. The first book on standard methods of water analysis was produced in 1905 (1). Then, in 1908, the next great discovery occurred. It was demonstrated that the application of chlorine to water supplies in small amounts could be depended upon to safeguard water supplies. This demonstration was made at the Boonton Reservoir of the Jersey City supply. With that discovery all facets of the knowledge needed to control the safety of water supplies were available. The single problem remaining was to put that knowledge into practice. That was an immense task that required the services of trained treatment plant operators who were not available. To meet this problem, it was necessary to train operators and to do the job as speedily as possible.

The solution was the establishment of in-service training courses. These early courses were not the formal type known today, but consisted primarily of discussion periods in which the experiences of the various operators were exchanged. As far as is known, these early courses were started by the public health workers about 1911 or shortly thereafter. The size, number, and

quality of the courses grew and expanded to the extent of enlisting the facilities of the colleges and universities to help prepare and conduct the training courses. The end result of all this activity was that waterborne typhoid fever and dysentery were gradually subdued until they are now a thing of the past. This was a great accomplishment, and the water industry can be proud of the part it played in this program. Some of the credit, however, should be attributed to the magnificent contribution made by in-service training.

The in-service training discussed above was for treatment plant operators only. That type of training must continue indefinitely—to train new men not only in the art of controlling water safety but also in the art of producing improved water quality. This is an important obligation. The industry is meeting the water safety requirements, but it falls short of meeting water quality needs. Meeting that obligation will also require the education of the public to want and demand better water quality.

Types of Training

The success of training courses for treatment plant operators caused many water works executives to wonder if similar success would result from training designed for other operating divisions of a utility. Thus, the past decade saw many types of in-service training courses attempted. The 1-day vocational training courses typical of the efforts made to provide training on a regional basis, are set up to fill a specific need. In this case it is the training of the small-town operator.

These courses feature all kinds of practical demonstrations, such as: how to repair a leak in a water main; how to repair meters; how to set meters; how to disinfect a water main; how to insert a valve in a live main; how to install a corporation cock; and how to install a service line. Such courses provide the maintenance and operating employee with practical knowledge on how best to meet everyday problems. This type of training is elementary and should be a part of any well rounded training program in the industry.

At least two states, South Carolina and West Virginia, have developed correspondence courses for in-service training. The South Carolina program is administered by a college, and in West Virginia the state health department is in charge. Such courses require a considerable amount of time on the part of the administrative officer. Returned papers must be corrected, and, if the course is properly handled, the corrected papers should be returned to the trainees with enough explanation to show where errors were made. The great amount of work involved in the administration of correspondence courses may restrict their popularity.

In Michigan, extension courses of high caliber have been developed to a degree that they are a credit to the water industry. The courses are taught by college professors chosen by the Committee on Education of the Michigan Section of AWWA. Professors are selected because of their knowledge of water supply and possibly because of their popularity with water works personnel. The subject material of the courses varies considerably, including courses in water chemistry, water bacteriology, water biology, water works engineering, geology, and other related subjects. A typical course is scheduled for 16 weeks' duration with one 3-hr class per

week. The classes are held in the evening, usually at some public school building where facilities for teaching are adequate.

College textbooks are required for each course, and lessons are assigned each week. Although no college credit is given for the completion of a course, the caliber of the teaching and of the material is at the college level. The courses are developed to cover subject material which relates almost directly to water supplies. These courses are developed under the joint sponsorship of the Michigan Section, the state health department, and one or more colleges. Usually the Department of Public Instruction is also involved to the extent of financing the stipend and traveling expenses of the teacher. These courses are designed primarily for the technical staff of a water utility.

Another type of training course developed in Michigan is unusual in that only one subject is covered in each symposium. The course consists of a 2–3-day meeting held biennially at a local university. The course is designed exclusively for water works administrators. Such subjects as safety in the water works industry, nuclear energy as applied to the industry, or taste and odor control form the program for these meetings. The thought back of the development of this type of training course is to provide a forum at which major problems of current interest to water utility executives may be discussed by people well versed in the subject material being reviewed. This type of course is designed to increase the knowledge of utility executives by providing a complete review of the known facts. The time spent on each subject is considered adequate to cover the material completely. In other words, the course provides an intensive review of the subject chosen for discussion. This type of course was developed jointly by the Michigan Section and the University of Michigan.

Finally, in-service training courses for water works executives are receiving attention. The outstanding example of this type of course is one sponsored jointly by the Illinois Section of AWWA and the University of Illinois. This course is limited to about 40 water works administrators each year. It is a 5-day course which concentrates on subject material of importance to water works administrators. This course is providing the type of training which is sorely needed and thus can be expected to accomplish much good. It is at the executive level that the greatest advances can now be made in the industry. This type of school deserves to be duplicated in most, if not all, AWWA sections.

Committee Report

In 1952, the Committee on Education of AWWA studied in-service training and certification in the industry. In its report (*2*) one of the interesting statements is that in 1951 more than 2,200 water works employees in the US attended short courses. That number of people would represent a fairly large college or university. Attendance at the courses varied from 16 to almost 600. A total of approximately 13,300 man-days were involved in the training program in 1951. These are impressive figures and indicate the interest of the industry in this type of training.

One of the recommendations of the report was that: "short courses with higher educational prerequisites should be developed for water works personnel." In other words, the committee is saying that the quality of the short

courses should be enhanced as well as the educational qualifications of the employees. It was with that thought in mind that the education committee developed outlines for six in-service training courses. Those outlines were printed in *Willing Water* in October 1955 (*3*), and covered six courses entitled: [1] Basic Water Works Operation; [2] Advanced General Water Works Operation; [3] Ground Water Production and Treatment; [4] Surface Water Production and Treatment; [5] Water Distribution; and [6] Water Works Management.

At the St. Louis Convention of AWWA in 1956, the Committee on Education decided to ask the Board of Directors for permission to develop the six manuals based on the outlines printed in *Willing Water*. The Board of Directors approved of the plan and work on writing the manuals was started at once. About 80 members of the Association are contributing writing assignments in the preparation of the manuals. The manuals, when completed, will total over 800 pages of printed material and represent a good sized book; they are being prepared with the thought of enhancing the quality of training schools. They may be used as textbooks for in-service training or may be used independently for self-improvement. [At the 1957 Annual Conference at Atlantic City, N.J., the Committee on Education (4260 M) revised the outline and combined some of the courses, in order to avoid duplication of material. Manuals are now planned for four courses: 1—Development of Water Supply; 2—Treatment of Water; 3—Distribution of Water; and 4—Water Works Management. Two of the manuals are currently being prepared for publication, and editorial work on the remaining two is expected to begin in early 1958.]

In-service training has become a recognized and an established part of water utility personnel training. It has accomplished a great deal, but this type of training has much more to offer than has been accepted by our industry to date. In-service training will grow in quality and stature as the years go by. The one thing which the water works industry must guard against, however, is considering in-service training as an end in itself or as a substitute for formal education.

Certification

As mentioned previously, the AWWA Committee on Education wrote a report covering both in-service training and certification of water utility employees. The findings of the committee on certification as expressed in that report (*2*) were:

1. Certification programs are growing in number in the United States and at the end of 1952 totaled 23. New Jersey was the first state to have a certification program, starting in 1918. It was not until 1931 that the second state, Michigan, developed a certification program. Since that time, however, these programs have been growing in number quite steadily.

2. The great majority of certification programs are of the voluntary type as differentiated from the compulsory or legislative supported type. Sixteen of the 23 programs are of the voluntary kind.

3. Compulsory certification programs are superior to voluntary programs when analyzed according to number of eligible operators certified, public health factors, quality of the operators, morale of the operators, the operator's

financial status, and removing the jobs from politics. Thus certification by state law is the final objective to be sought in any certification program.

4. Reciprocity among the states practicing certification appears to be desirable in the opinion of the majority; the need for reciprocity, however, is not established.

5. Of the 23 states with certification programs, 22 require the successful completion of an examination to become certified.

6. Revocation of certificates for cause is firmly established, but so far has not been practiced.

7. Certification programs do not attract college graduates to the water works field. Economic conditions apparently control such decisions.

These findings of the committee clearly indicate that certification has much to offer. The next step would be to work toward compulsory certification, which has proved advantageous wherever tried.

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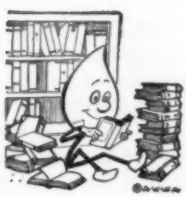

Corrosion and Tuberculation of Cast Iron

Thurston E. Larson and R. V. Skold

A paper presented on May 15, 1957, at the Annual Conference, Atlantic City, N.J., by Thurston E. Larson, Head, Chemistry Section, and R. V. Skold, Research Assoc., both of the Illinois State Water Survey, Urbana, Ill. This report was prepared for AWWA Committee 2810 D—Effect of Purification Methods on Water Main Carrying Capacities, whose function is to advise, assist, and supplement the study being conducted on this subject by the Illinois State Water Survey. The study described is being supported by Research Grant G-4007 (R) from the National Institutes of Health, USPHS, Washington, D.C.

AN evaluation of operation and field data has been made for eleven water plants using Great Lakes water. Laboratory studies indicate the interrelated influences of chloride, alkalinity, pH, calcium, silica, and free and combined chlorine on the corrosion of steel and cast iron by water. Free chlorine was found to be corrosive to steel in water of Great Lakes quality. The greatest single influence on the corrosion of cast iron was found to be the concentration of calcium. Inconclusive results have been obtained to date on the influence of free and combined chlorine and silica on corrosion of cast iron. Tuberculation, a secondary result, or byproduct, of corrosion, was not observed until experiments were made to determine the influence of calcium and the saturation index.

From a study (*1*) of available carrying capacity data, it was concluded:

> There is no completely satisfactory criterion for external measurement of the physical condition of the pipe interior. This is not a criticism of flow tests when carefully made to determine carrying capacity, however, but an evaluation to indicate a limitation on the extent to which such tests can be used, even comparatively, to determine a change in pipe roughness, specifically tuberculation.

Specific evaluation of treatment methods, or of the relative quality of treated waters, at the eleven water plants studied was not possible due to multiple treatment changes, lack of consistent treatment, or deficiencies in records, sampling, and analytical procedures.

Laboratory Investigations

An empirical relationship (*2*) was developed between the rate of corrosion and of polarization (change in potential per unit of applied-current density) with very low applied-current density (measured in milliamperes per square decimeter). This relationship is confirmed on all specimens by weight loss measurements at the end of tests.

This method has proved to be invaluable as a laboratory tool as corrosion rates very often do not reach equilibrium for periods as long as several weeks (*3*) and as it permits the measurement of change in rates after the addition of rate-influencing ingredients into the environment.

The laboratory tests are performed with metal specimens totally immersed in solution, saturated with air, at room temperature, with carbon dioxide used for controlling pH. The apparatus provides a constant velocity of the specimen in a vertical circular path (*4*). Cast-iron specimens are machined and abraded with No. 120 grit paper and degreased prior to use. At the end of the tests, the specimens are cleaned electrolytically for 5 min in 10 per cent ammonium citrate prior to the determination of weight loss, in terms of milligrams per square decimeter per day.

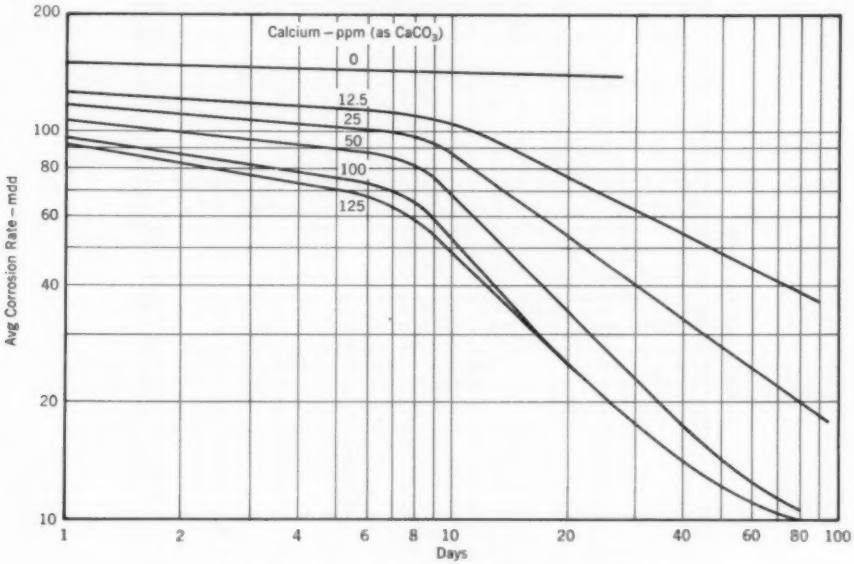

Fig. 1. Summary of Calcium Effects on Corrosion

Overall averages of test results are shown. Water velocities ranged from 0.08 to 0.85 fps; alkalinity was 125 ppm (as calcium carbonate); and tests were run at room temperature.

Corrosion of Cast Iron

The susceptibility of cast iron to corrosion is unlike that of steel. It has been pointed out that a great difference in susceptibility to corrosion exists between "as cast" or annealed cast-iron and machined specimens. It was found (*3*) concerning water with no calcium:

> Unlike in corrosion of steel, machined or ground surface cast-iron specimens were not found to resist corrosion to any significant degree in any type of water under test. Tests made with unground "as cast" or annealed cast-iron surfaces gave evidence of relatively high resistance to corrosion by water of Great Lakes character in the *absence of calcium*. It appears that the natural surface skin of iron oxide formed during the process of manufacture is largely responsible for the excellent reputation enjoyed by cast iron as resistant to corrosion.

By correspondence and by visits to foundries manufacturing cast-iron pipe,

it was learned that the interior of all centrifugally cast pipe is partially ground for the purpose of reducing roughness prior to the application of the coal-tar coating or cement lining. In this step, most pipe interiors have been ground to the extent of 10–50 per cent of the surface.

These facts would indicate that tuberculation results from action of a non-inhibited water on holidays, or minute holes, in those portions of the tar coating

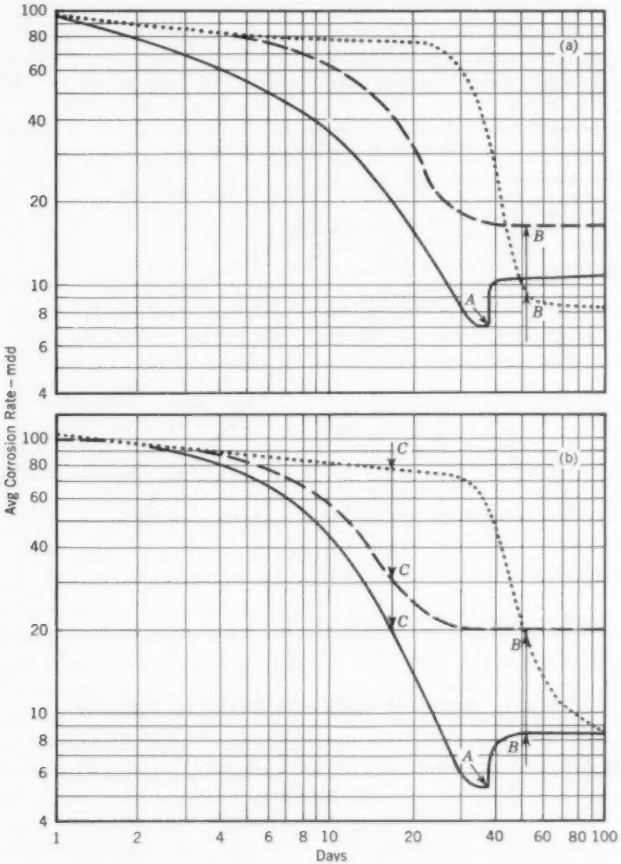

Fig. 2. Tests Made at 0.085-fps Water Velocity

In both tests, specimens were immersed in 2.5 equivalents per million (epm) of calcium carbonate. The water velocity was 0.085 fps. The dotted lines represent specimens with a saturation index of −0.8 and a pH of 6.8; the dashes, specimens with a saturation index of −0.3 and a pH of 7.3; and the solid lines, specimens with a saturation index of 0.2 and a pH of 7.8 (at Point A, *56 ppm sodium chloride was added, and the saturation index was reduced to −0.1 and the pH to 7.5). At Point* B, *0.5 ppm chlorine was added to all three solutions. At Point* C, *in Fig. 2b, 5.0 ppm silica was added to the three solutions.*

which cover the ground portions of the interior of the pipe.

A very considerable amount of effort was devoted to: [1] preparing uniform tar coating on machined specimens and producing artificial holidays of 0.02–0.06-mm diameter for the purpose of simulating the type of coated pipe reported to be in service in many municipalities; and [2] studying the effect of

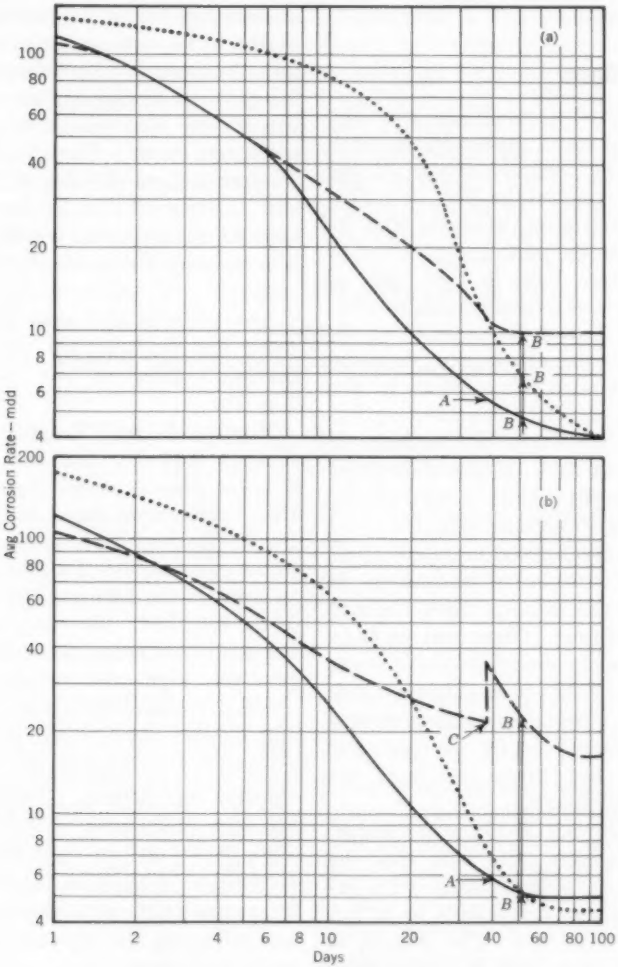

Fig. 3. Tests Made at 0.34-fps Water Velocity

In both tests, specimens were immersed in a 2.5-epm solution of calcium carbonate. The water velocity was 0.34 fps. The lines represent the same conditions of saturation index and pH as in Fig. 2, with the saturation index of the third solution lowered to −0.1 at Point A. *At Point* B, *1.0 ppm* NH_2Cl *was added to all three solutions. At Point* C, *in Fig. 2*b, *56 ppm sodium chloride was added to one of the solutions.*

water quality specifically at the holidays. Because the results were inconclusive due to difficulties of reproducing the coating and the apparent porosity of the very thin coating necessary for these tests, this approach was abandoned.

Calcium Effects

With uncoated machined cast-iron specimens in water containing calcium, an interesting overall average of the results is indicated in Fig. 1. This broad generalization indicates that irrespective of the saturation index; of velocities from 0.08 to 0.85 fps; of minor variations in the chloride to alkalinity ratio; and of the presence or absence of chlorine, chloramine, or silica, the concentration of calcium in the presence of alkalinity is a primary factor in the inhibition of corrosion of machined cast iron. It also shows that a certain length of time is required for effectiveness to become apparent.

In this generalization representing all tests, there are broad variations, as much as tenfold in some cases, for each level of calcium. These will be indicated for specific modifications in water quality at the 125-ppm calcium hardness level. These data are represented as smooth lines from the average rates determined five times per week for triplicate specimens.

Figures 2a and 2b show the reduction of corrosion rates with time for three degrees of saturation with respect to calcium carbonate at a low velocity of 0.085 fps. The amount of calcium carbonate was 2.5 equivalents per million (epm). The decrease in rate of corrosion occurred most rapidly for the water with a saturation index of −0.1 and least rapidly for the −0.8-saturation water.

The specimens in −0.3-saturation water leveled off at a higher final corrosion rate than either of the other two. It should be indicated that these specimens at this saturation index showed small dark reddish spots or growths surrounded by an overall whitish red deposit prior to the addition of chlorine, and continued to form tubercles. Similar growths developed, but to a lesser extent, on the specimens in −0.1-saturation water. The effect of adding 56 ppm sodium chloride is also apparent. (Figure 3 shows that the simultaneous reduction of saturation index was not responsible for this increase in rate.)

The addition of 5 ppm silica at this point had no apparent effect on the corrosion rate, as can be seen in Fig. 2b.

Figures 3a and 3b provide similar data at 0.34 fps, but with combined chlorine present rather than free chlorine. The more rapid reduction and the lower final corrosion rates testify to the effectiveness of a greater velocity to improve the diffusion rate of calcium as the inhibitor. No effect of reducing the saturation index is noted, with this relatively high calcium content.

Similar tubercles, but smaller in size and number, were noted in the −0.3-saturation environment than when free chlorine was present. Parenthetically, the free- and combined-chlorine levels were maintained in these tests without substantial increase in chloride content by periodically withdrawing portions and adjusting the mineral composition with fresh water.

With free chlorine added, it was seen that round knobs of $\frac{3}{16}$-in. diameter protruded as much as $\frac{1}{8}$ in. A clear indication of tuberculation was the pitting evident on cleaned specimens.

Figure 3b shows results almost identical with Fig. 3a and includes clear evidence of the effect of adding 56 ppm sodium chloride to the −0.3-saturation specimen.

One series of tests was made with raw Lake Michigan water transported to Urbana. Single machined cast-iron specimens in each of six modifications in quality corroded in the manner indicated in Fig. 4 and Table 1. The effect of increasing chloride content resulting from chlorine and chlorine-ammonia treatment are indicated to increase the corrosion rate. Tubercles of greater or less magnitude were noted on all specimens, and pitting was also observed.

ratio, and chlorine, the results of four test conditions are indicated in Fig. 5. These specimens showed tuberculation in all cases, with or without chlorine or chloramine, and were similar to the −0.3-saturation index specimens as indicated in Fig. 2 and 3 with 125-ppm calcium hardness.

Although the calcium concentration was lower than in Fig. 2 and 3, the rate of corrosion after 1 day was less than that when 125-ppm calcium hardness was present, since the velocity was greater and the pH higher. Rate of approach to equilibrium is lower.

The influence of the chloride-alkalinity ratio is shown by comparing

TABLE 1

Corrosion and Tuberculation With Lake Michigan Water

Specimen	Treated*	pH	Chlorine	Final $\frac{Cl^-}{Alky.}$	Tubercles	Pits	Final Corr. Rate *mdd*
5	no	8.0	none	0.16	rounded	shallow	25
3	yes	8.0	none	0.16	rounded	shallow	30
4	yes	8.0	NH_2Cl	1.05	small	shallow	49
6	no	8.0	Cl_2	1.05	large	deep	55
2	yes	7.4	Cl_2	1.32	large	slight	73
1	yes	7.4	NH_2Cl	1.50	small	none	90

* Treated with 17 ppm alum and filtered in laboratory.

It should be emphasized that these data are less significant due to the increase in chloride concentration over the 85-day period, resulting from continuous chlorination. Careful analysis of the other variables, however, indicate that fruitful results may be obtained by the careful use of specimens over extended periods of study with the various waters or their modifications in any treatment plant, and by adequate comparison with observations in the distribution system.

To consider further the relative influence of the calcium concentration, saturation index, the chloride-alkalinity

the top and bottom curves; the intermediate ratio of 0.3 is also indicated by the two middle curves. The relative influence of free and combined chlorine appears to be of only minor significance.

Of particular significance is the rise in corrosion rate in one of the solutions at the 84th day, when the pH was permitted to drop to 6.7. On detailed examination of the data, it often appeared that an inadvertent drop in pH of 0.1 unit increased the corrosion rate by about 8 mdd.

Currently, studies have been inaugurated with sulfate, rather than chloride,

to establish the relative influence on the corrosion rate and on tuberculation.

Conclusions

The finding that calcium in the presence of alkalinity, regardless of pH or saturation index, is an effective inhibitor to corrosion is not inconsistent with theory and experience. The basic corrosion reaction is conducive to the formation of calcium carbonate at the point of corrosion even though the water environment is below saturation with respect to calcium carbonate. The rate at which such deposition may take place is increasingly improved by higher concentrations of calcium or presumably the alkalinity. The rate is also increasingly improved by higher velocities, and is further improved by pH adjustment to or above the saturation pH for calcium carbonate.

The finding that tubercles form under conditions of nearly complete protection is consistent with the well-known action of inhibitors to induce pitting corrosion, rather than general corrosion, when present in insufficient concentration to produce complete protection. This is confirmed by the observation of pitting corrosion on specimens which showed tuberculation. The fact that tubercles form is apparently due to the deposition of a supporting structure of calcium carbonate with or in the normal corrosion product of ferric hydroxide in aerated waters.

If the saturation index is not sufficiently close to zero or the concentration of calcium or alkalinity are too low, the more rigid supporting structure is not developed, although appreciable protection is afforded by calcium carbonate embedded in the rust deposit from generalized corrosion. This was observed on specimens in waters of −0.8-saturation index at pH 6.8 in Fig. 2 and 3. These specimens were

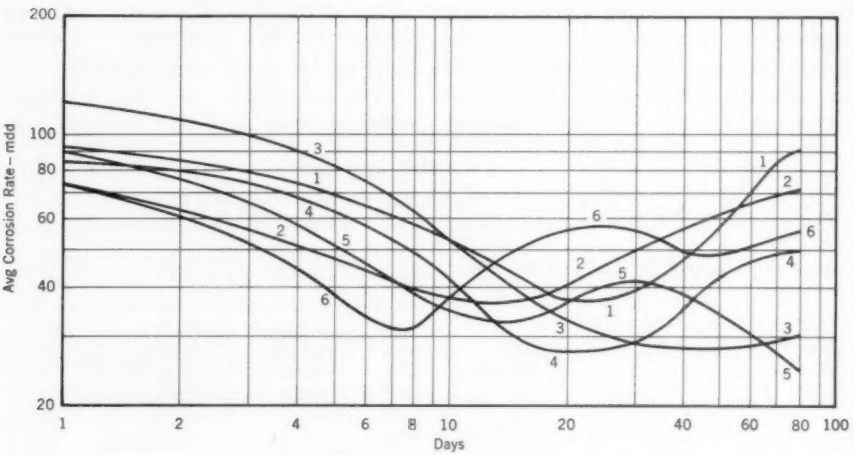

Fig. 4. Tests on Lake Michigan Water

Tests were made on cast-iron specimens, with conditions that varied as indicated in Table 1.

coated with a whitish red deposit of sufficient thickness (about $\frac{1}{16}$ in.) and hardness to continue to adhere even though they were cracked for distances of $\frac{1}{2}$ in. There were no pits under this coating, and it served as an effective barrier to diffusion of oxygen and other corrosive ingredients.

As a tentative conclusion, it appears that the problem of designing water treatment to avoid tuberculation of cast iron is limited to such waters as already contain inhibitors in insufficient concentrations to provide complete protection. This problem is jointly concerned with maintaining or creating a velocity of water flow which is sufficient to provide adequate diffusion, transport, or movement of the inhibitor to the point of effectiveness.

Future Studies

A number of questions remain unanswered. Aside from the need for further data with waters of quality different from Great Lakes water, it will be of interest to establish the relative chemical mechanisms that contribute to the formation and growth of tubercles. Several suggest themselves and are

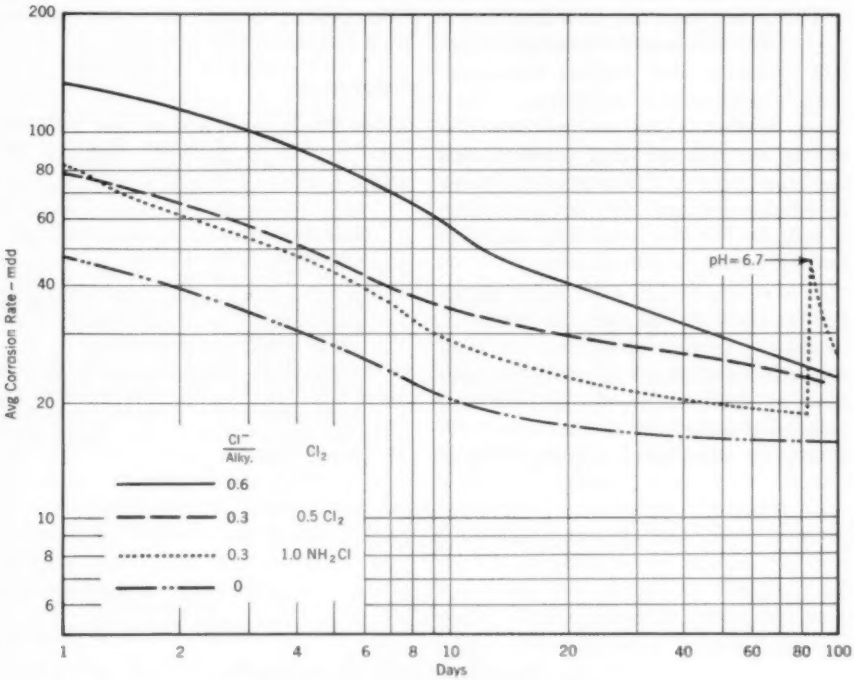

Fig. 5. Effects of Chloride-Alkalinity Ratio

All tests were made with a water velocity of 0.85 fps. Calcium concentration (as $CaCO_3$) was 31 ppm; alkalinity (as $CaCO_3$) was 25 ppm. The saturation index was −0.25, and the pH (except as indicated) was 8.0.

being investigated to provide a more clear understanding of their interrelationships. More data are required to evaluate other supplementary inhibitors with regard to specific qualities of water.

Study is also required on means of chemically removing existing tubercles without resorting to drastic means and without creating a more corrosive environment.

The data presented here and previously infer that free chlorine can stimulate corrosion and possibly tuberculation under certain conditions. Evidence of this is, as yet, inconclusive. It has been shown that tuberculation can also occur in the presence of combined chlorine and also in the absence of either free or combined chlorine under certain conditions.

It is to the credit of the water works profession that through the years of its history such great interest has been expressed and so much work has been done on the problem of corrosion and occasional associated tuberculation. It is, on the other hand, amazing that so little basic work has been developed by research agencies on this very fertile field of research, although what has been accomplished is significant.

Acknowledgment

The physical facilities for the laboratory investigations were furnished by the Illinois State Water Survey. The authors wish to thank Mary C. Brooks and Wesley Y. Walters of the Illinois State Water Survey for their laboratory assistance.

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Protective Coatings for Water Distribution Systems

Robert F. McCauley

A paper presented on May 15, 1957, at the Annual Conference, Atlantic City, N.J., by Robert F. McCauley, Assoc. Prof., Civil & San. Eng., Michigan State Univ., East Lansing, Mich. This report was prepared for AWWA Committee 2840 D—Research on Protective Coatings for Water Distribution Systems. The study described is being supported by Research Grant G-4627 from the National Institutes of Health, USPHS, Washington, D.C.

THIS report is a brief summary of research done at Michigan State University on protective coatings under a grant from the National Institutes of Health. The grant was received in September 1956, so that at the time of preparation of this report work had been underway for about 7 months.

At this time no reliable data are available for presentation, although a number of preliminary test runs have been made. Most of the 7-month period has been spent in procurement of personnel, in preliminary training, and in the purchase and construction of equipment. Almost all of the necessary equipment has been installed, and serious work is now beginning.

Objectives of Project

In order that the objectives of the project may be understood, some brief review of the history of this work and of its present status is desirable. Natural protective coatings, usually of calcium carbonate or mixtures of calcium carbonate and corrosion products, are, of course, widely used in water works practice for prevention of excessive corrosion and for overcoming red-water problems. In the water works field there is fortunately an excellent bibliography on this important topic, and at the present time much of the necessary theoretical basis for a proper understanding of the basic principles has been formulated. Excellent papers have appeared in the literature during the past 20 years (*1–14*).

Many of the papers have been pointed toward establishing a relationship between the tendency of calcium carbonate to deposit or dissolve in a water distribution system and the pH, solubility product constant of calcium carbonate, ionization constants of carbonate and bicarbonate ions, and temperature of the water. The theoretical and applied work just mentioned has been well tested in the field of water works practice and has been found useful, although in some respect inadequate.

At this time the following limitations exist with respect to the use of calcium carbonate coatings for anticorrosion purposes:

1. Coatings are in some instances dense, hard, and uniform; in other instances they are soft, rough, and permeable. Thus, good anticorrosion protection is obtained under some circumstances, while under other conditions almost no protection is afforded. No

satisfactory procedure for assuring satisfactory protective coatings under all normal operating conditions now exists.

2. The relationship between the formation of coatings and the dissolved oxygen level in a water has not been completely established. American water works practice is generally to reduce dissolved oxygen to the minimum possible level. European workers have suggested that some corrosion is desirable for the development of good protective coatings, and do not completely agree with the American theory that dissolved oxygen is undesirable in water distribution systems.

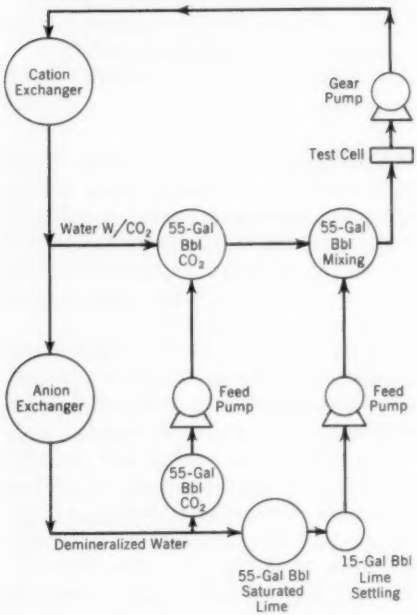

Fig. 1. Arrangement of Apparatus for Corrosion Studies

The only metal in the system is the iron or platinum test cell.

3. Almost all laboratory and applied work has been in connection with the development of calcium carbonate coatings. It has been recognized for many years, however, that the coatings developed in water mains are often mixtures of calcium carbonate, iron hydroxide, silica, and other materials. Moreover, it has been pointed out by Larson (*1*) that magnesium hydroxide and silica may be coprecipitated in some instances with calcium carbonate. The resulting coating is soft and has slight anticorrosion value.

4. Little is known regarding the effect of ions such as chloride, sulfate, hydroxide and bicarbonate upon the kind of calcium carbonate or other protective coating which is developed. Information regarding other important physical and chemical factors which influence the development of coatings is equally lacking.

The purpose of this study is to uncover facts with regard to some of the above problems. Because of the nature of the problems, progress will be slow, and the objective will be to establish facts regarding the nature and development of these coatings, both chemically and physically. The findings may prove helpful to the water works profession, but the present work does not have this immediate objective. If the work is successful, however, it is the author's feeling that the end results will be most useful.

Equipment and Procedures

The work attempted in this study is best considered in terms of the previously mentioned problems which now prevent a full utilization of natural protective coatings for anticorrosion purposes: [1] variability in density, hardness, and permeability; [2] incomplete

information regarding the function of dissolved oxygen in determining the kind of coating developed; [3] absence of reliable data regarding the physical and chemical structure of coatings; and [4] absence of information regarding the effect of certain ions and other chemical and physical influences upon coatings developed.

Largely, the above difficulties stem from our incomplete understanding of

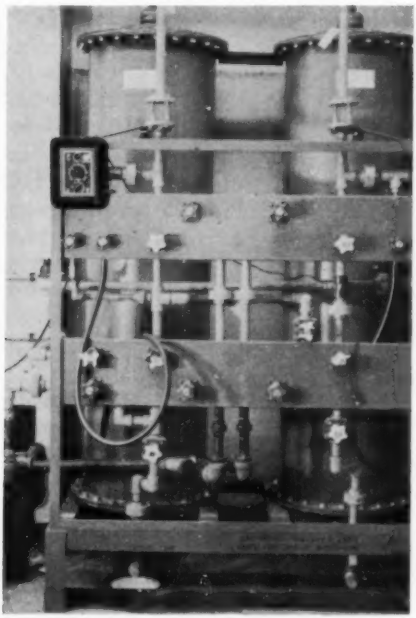

Fig. 2. Ion Exchange Units

the forces which influence the development of these coatings. Such understanding is not easily gained from studies on water distribution systems, since it is well recognized that differences in the chemical quality of most waters exist during different periods of the year and that even more important differences exist between the chemical quality of the water films surrounding a corroding distribution main or pipe and the quality of the water in the system. As Larson (*1*), and Strum (*2*), and many others have pointed out, anodic areas on these pipe walls are often acid and cathodic areas are alkaline with respect to the water of the distribution system. Thus, in a poorly buffered water a pH level of 5 or 6 may exist near an anodic area, while the level might at the same time be perhaps 8 in the distribution system and as high as 9 or 10 near the cathodic areas of the pipe walls.

The quality of water in the film which surrounds a corroding pipe wall unquestionably changes with time over a wide range of levels of pH and alkalinity due to the movement or quiescence of the water in the distribution main at various periods of the day and night. Also, water quality is not necessarily uniform in these films throughout the distribution system. The development of protective coatings is influenced by these differences in water quality and also by differences in temperature between summer and winter, as well as by any changes which may take place in a treatment plant or in the water source.

Because of these many variables, it was decided to begin the study in a system divorced from such influences. The equipment which is being developed, when perfected, should permit a study of each of the many variables under controlled conditions. As shown in Fig. 1, a device has been constructed which is designed to pass water of uniform quality through a test cell containing an iron specimen or platinum sheets, each about 1 in. by 2½ in. in area. The iron specimen or platinum sheets are the only metal in the system.

Piping is entirely plastic, as are the walls of the test cell. The gear pump * contains no metal exposed to the water, and was selected in order to avoid temporary increases in energy level which might occur in a centrifugal type pump.

Water is pumped from a 55-gal plastic barrel and passes through a second 55-gal mixing barrel, the test cell, gear pump, and a plastic-lined cation exchanger.† The effluent from the cation exchanger is demineralized except for dissolved carbon dioxide which is not removed. Figure 2 shows the ion-exchange units used.

A small flow from the cation exchanger is freed of CO_2 by an anion exchanger and passes to two 55-gal plastic barrels. One barrel is surrounded by a carbon dioxide atmosphere and the other contains saturated lime. A duplex feeder ‡ feeds saturated lime water and saturated CO_2 water into the suction line from the 55-gal storage barrel. It is hoped that a very uniform water containing only calcium, bicarbonate and carbonate ions (influenced, of course, by hydroxide and hydrogen ions) and by dissolved CO_2) can be passed through the test cell. Sampling cocks, a flow meter, valves, and other accessories for necessary control and for sampling are provided as required.

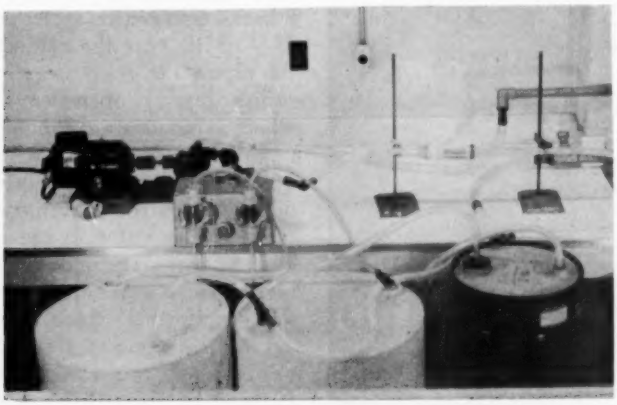

Fig. 3. Units of Laboratory Apparatus

This is a view of part of the equipment—including the test cell—diagramed in Fig. 1.

Whether the device will be satisfactory is yet to be determined, since work has just begun on this phase. If it is satisfactory, some means of temperature control may have to be considered. Figure 3 shows a recent photograph of this equipment, whereas Fig. 1 is a flow diagram of the system.

A second and less complicated apparatus is shown in Fig. 4. In this

* The gear pump was purchased from the American Hard Rubber Co., New York, N.Y.

† The cation exchanger is Model HB 490, Illinois Water Treatment Co., Rockford, Ill.

‡ The duplex feeder used was a Neusol, product of Infilco, Inc., Tucson, Ariz.

system water is stored in the 55-gal polyethylene barrel and is circulated through the test cell by an all-rubber centrifugal pump. The second arrangement has a material advantage over the first because of simplicity, but is less flexible. Difficulty may develop because of the production of colloids over a period of operation or because of changes in alkalinity and pH due to formation of calcium carbonate coatings within the test cell.

The heart of each apparatus is a test cell. Two cells have now been constructed, one being a simple housing for a cast-iron or platinum sample, which, as previously mentioned, is the only metal in the system. The second test cell (Fig. 5) has been constructed in such a way as to permit measurement of the open-circuit potential of a corroding cast-iron specimen. Potentials are measured with a potentiometer connected to the test cell specimen and to a reference calomel electrode.

The plan is to measure the potential of corroding cast-iron specimen with waters which vary in dissolved oxygen, pH level, alkalinity, calcium, soluble iron, and level of calcium carbonate supersaturation. Similar potentials for each of the waters tested will then be imposed upon a platinum sheet placed in the same test cell. In this way it is anticipated that definite information can be obtained with regard to the formation of calcium carbonate coatings under specific chemical and physical conditions.

The factors which may influence the kind of coatings developed are numerous. Some of the most important are: [1] alkalinity; [2] pH; [3] dissolved oxygen; [4] potential of corroding metal; [5] calcium carbonate and ferric hydroxide colloids; [6] presence of dissolved salts; [7] chlorine; [8] ions of dissolved salts including calcium, magnesium, iron, silicate, sodium, chloride, and sulfate; [9] temperature; [10] polyphosphates; [11] level of supersaturation of materials being deposited; and [12] velocity of flow.

Calcium Carbonate Supersaturation

One further matter of interest in connection with this project is the manner in which the tendency of calcium carbonate to deposit is measured. In addition to the conventional methods, which include the Enslow stability indicator (*3*), Langelier's saturation index (*4, 5*), and Ryznar's stability index (*6*), a method of momentary excess suggested by John Dye, superintendent of the Lansing, Mich., water treatment plant, is being used. This method measures the true supersaturation of calcium carbonate, and has been well tested in the Lansing water system. It should prove a useful tool for these studies, since this excess measures the driving force of the chemical excess of dissolved calcium carbonate and is, therefore, quantitative in nature.

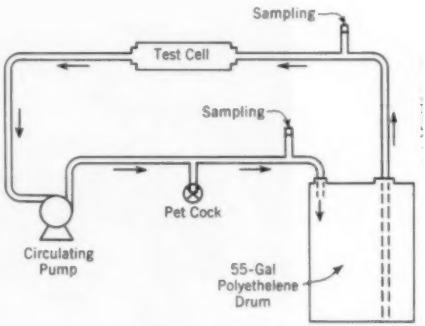

Fig. 4. Arrangement of Simplified Laboratory Apparatus

Studies of Coatings

Coatings developed in the study will be subjected to analysis by X-ray diffraction and by petrographic methods. In addition, observations with regard to hardness, porosity, and general appearance will probably be desirable. Other than for the above general procedures, no serious consideration has yet been given to the matter of specific studies upon the coating materials, since present emphasis is upon development of equipment and upon devising techniques for depositing the crystalline coating materials upon the test platinum or iron specimen.

The equipment devised for this work contains no metal other than the test specimen or platinum sheets. It is hoped that in this way the true effect of many of the variables which affect the formation of protective coatings can be studied.

After satisfactory procedures for developing coatings are devised, the coating materials will be studied by X-ray diffraction and petrographic methods in order to investigate their physical structure.

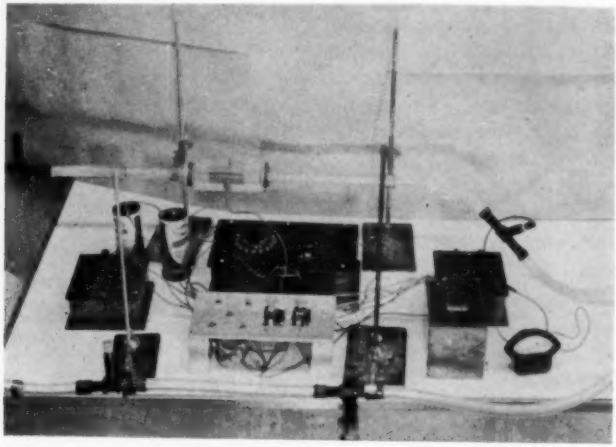

Fig. 5. Test Cell With Potentiometer and Calomel Electrode

Conclusions

Work has been underway for 7 months upon a study of the development of protective coatings in water distribution systems. Most of this time has been spent in the construction and purchase of equipment. Only a few preliminary test runs have been made. No useful data are yet available.

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Studies of Cadmium and Chromium Solubility and Toxicity

Robert D. MacKenzie, C. A. Hoppert, and R. U. Byerrum

A paper presented on May 15, 1957, at the Annual Conference, Atlantic City, N.J., by Robert D. MacKenzie, Research Instructor; C. A. Hoppert, Prof. of Chemistry; and R. U. Byerrum, Assoc. Prof. of Chemistry; all of Michigan State Univ., East Lansing, Mich. This report was prepared for AWWA Committee 2610 P—Chromium and Cadmium Solubility and Toxicity.

THIS study was proposed to determine the effect of prolonged ingestion of small amounts of cadmium and chromium in the drinking water.

Cadmium

Since the last report by Decker, Hoppert, and Byerrum (*1*), work has been started to study the effects of cadmium on certain enzymatic processes. The enzyme formyl-L-glutamic deformylase was isolated from guinea pig liver. The specific activity of the enzyme was increased 11.2 times during purification from the crude extract. As judged by data obtained from electrophoresis of the purified enzyme in both phosphate and veronal buffer, there was one component present in the purified preparation. This was assumed to be identical with the active enzyme. The specific activity (micromoles of glutamic acid produced from formyl-L-glutamate per milligram of protein per hour) of the purified enzyme (6.48) was enhanced by Co^{++} (7.72), whereas Cd^{++} and Fe^{++} depressed the activity slightly (6.02 and 5.41, respectively).

No detectable amounts of cadmium were found in the blood of the dogs on the long-term study at any of the levels given. This would indicate rapid removal of the cadmium from the blood, probably by the liver and kidney. Dogs which have been receiving up to 10 ppm of Cd for 2½ years have shown no gross abnormal effects or blood changes.

The results of the study of cadmium in the drinking water can be summarized as follows: The emetic property of cadmium was found to occur at a concentration as low as 5 ppm when the temperature was high and the dogs drank large volumes of water. Up to 10 ppm, however, is being given with no untoward effects when temperatures are lower and less water is ingested. Although no pathological changes have been observed in rats after 1 year at even the 10-ppm level, there was indication of a significant accumulation of cadmium in the kidney and liver of rats ingesting as low as 0.5 ppm of cadmium. Studies started indicate that cadmium may influence certain enzyme systems. Formyl-L-glutamic deformylase activity was found to be slightly depressed by cadmium.

Chromium

The long term studies using dogs and albino rats were also described by Decker, Hoppert, and Byerrum (*1*). The results of the rat studies indicated a level of intake at approximately 8 ppm of chromate ion, below which the rat can eliminate the amount taken in and, therefore, no great retention occurs. Above this level there is a great increase in retention.

Three experiments concerned with absorption and distribution of chromium have been completed using radiochromium (Cr^{51}). In the first experiment, two groups of rats weighing about 250 g were used. The first group was fasted for 24 hr, and the other was fed *ad libitum*. Both groups were then administered the radioactive element by stomach tube, and were then placed in metabolism cages. Individual rats were killed at 6, 24, 72, and 168 hr. Blood, stomach, intestine, liver, kidney, brain, salivary gland, spleen, feces, and urine were collected and the radioactivity of each determined. The results indicated that about 5.5 per cent of the administered dose was absorbed in the fasted animals, and only 2.6 per cent in the nonfasted. Though most tissues decreased in activity and approached zero with time, the spleen gained in activity again after 72 hr.

In an attempt to explain the difference in absorption between the two groups, a second experiment was set up based on the observation that hexavalent chromium is absorbed into the red blood cell whereas trivalent chromium is not. Half of the rats were fasted for 24 hr. After Cr^{51} was administered by stomach tube, the rats were bled from the heart 4 hr later. The results showed that fasted animals averaged 459 counts per minute (cpm) per milliliter of whole blood and the ratio of activity of red blood cells to plasma was 1:4.76, whereas the nonfasted animals averaged 261 cpm per milliliter of whole blood, and the ratio was 1:8.8. This suggests that part of the hexavalent chromium is reduced to trivalent in the stomach, but the extent is influenced by the presence of food in the stomach.

A third experiment was set up to determine the influence of both valence states on each other. To accomplish this three groups of rats were used. The first group was injected with hexavalent chromium, the second with trivalent, and the third with equal parts of both. The activity used was the same as in the second experiment, but was injected directly into the intestine. There was a larger activity in the blood of the fasted animals given hexavalent chromium (2,500 cpm per milliliter of whole blood) than the nonfasted (1,098 cpm). In comparing ratios of activity between red cells and plasma, the ratios were appreciably smaller than those found in the second experiment, namely 1:1.67 for the fasted and 1:3.17 for nonfasted animals. The activity found in rats given the equal mixture corresponds closely to the values in the second experiment for hexavalent chromium, but the ratios are smaller (1:2.2 and 1:4). This indicates that hexavalent chromium is absorbed to a greater extent than trivalent chromium, and that the reduction of hexavalent to trivalent is continual, with a large percentage being reduced in the stomach even in the fasted animals.

The long-term comparison between trivalent and hexavalent chromium also confirms the greater absorption of the hexavalent chromium. The tissues of

rats given hexavalent chromium contained nine times as much chromium as those receiving the equivalent concentration of trivalent chromium. Since no toxic symptoms or pathological changes were found, it indicates that rats have a relatively high tolerance for chromium.

Blood analysis for chromium in the dogs showed a trend similar to that found in the rat tissues analyzed; that is, an increase in accumulation occurred above 5 ppm chromate ion.

The results to date indicate that a maximum permissible level of chromate for the rat might be as much as 5 ppm. Although higher concentrations have thus far shown no toxic effects, the gradual increase of chromium at higher levels of intake may ultimately cause adverse effects.

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Correction

The panel discussion "Plastic Pipe in Water Supply Use" contained an error in the portion by Max K. Socha (April 1957 JOURNAL, Vol. 49, pp. 427–33). On pp. 429 and 430, Fig. 3 and 4 have been reversed—the photograph shown as Fig. 3 should accompany the caption of Fig. 4; that in Fig. 4 is described in the caption of Fig. 3.

Survival of Elevated Storage Tank in Suburban Kansas City, Mo. Tornado

Staff Report

A report based on information obtained from Edward E. Alt, Contract Repr., Chicago Bridge & Iron Co., Chicago, Ill., and from newspaper articles.

ON May 20, 1957, a tornado more severe than any ever experienced in the area, ripped through suburban Kansas City leaving 37 dead, 500 homes demolished, and 500 others damaged. Many commercial buildings—in some instances whole business districts—were virtually destroyed, as were schools, shopping centers, and other structures. In the Ruskin Heights-Hickman Mills area, a steel, elevated water storage tank * directly in the tornado's path was the only significant structure to withstand, practically undamaged, a core wind estimated by the weather bureau at 500 mph.

The tank (Fig. 1), built in 1953 for the Jackson County Water District No. 1, has a 400,000-gal capacity and stands 148 ft above its foundation. Supported

* Builder of the tank was the Chicago Bridge & Iron Co., Chicago, Ill.

Fig. 1. Tank Surrounded by Tornado Wreckage

by eight 30-in. diameter welded cylindrical columns, the tank has a 46-ft diameter and a 42-ft overall height. It was designed to withstand a 100-mph wind in accordance with AWWA standards (*1*), which specify an assumed wind load of 30 psf on vertical

Fig. 2. Aerial View Showing Tank and Tornado Path

The path of the tornado runs from bottom to top of the middle of the photograph. To the left of the tank are the remains of a school, to the right, a large shopping center which was demolished. In the foreground is the strewn wreckage of several homes and beyond the tower lie more destroyed homes and a high school building.

plane surfaces, 18 psf on projected areas of cylindrical surfaces, and 15 psf on projected areas of double curved surfaces.

Close examination of the foundation showed no separation between the column bases and the cement grout. Damage is limited to some chipped paint, caused by flying debris, and a slightly bent ladder. The tank remained plumb and required only tightening of the tower rods. Witnesses report that the tornado funnel was actually split by the tower, indicating that the tank was directly in its path (Fig. 2).

A heavy, woven-wire steel fence, which had enclosed the tank site, was flattened. Many of the fence posts had been torn from their concrete footings and a large section of the fence had been wrapped around the center riser pipe and supporting column. Debris of all kinds wreathed the tank structure and, at the top, a radio antenna leased by a construction firm was bent and twisted.

Approximately 200 yards northwest of the tank is a severely damaged elementary-school building and, about the same distance to the west, a demolished house. To the south are blocks of virtually flattened dwellings and, to the east and northeast, approximately 250 yards away, lies the Ruskin Heights shopping center, almost a total loss.

Several factors are considered as contributing to the remarkable survival of the tank. At the time the tornado struck, the tank was approximately three-quarters filled, providing an additional 1,200 tons of dead weight. The design of the structure—all welded construction, tubular column supports, and an ellipsoidal roof and bottom—has also been suggested as a factor.

Reference

1. Standards for Steel Tanks, Standpipes, Reservoirs, and Elevated Tanks, for Water Storage—AWWA D100, Am. Wtr. Wks. Assn., New York; *Jour. AWWA*, **48**:200 (Jun. 1955).

Techniques in the Use of Liquid Alum

Panel Discussion

A panel discussion presented on May 16, 1957, at the Annual Conference, Atlantic City, N.J. Leo Louis, Vice-Pres. and Gen. Mgr., Gary-Hobart Water Co., Gary, Ind., who also participated in the panel, presented material largely covered in his article "New Chemicals Used in Treatment at Gary," in the December 1956 issue of the JOURNAL.

Introduction—*Norman E. Jackson*

ALUMINUM sulfate has been the most widely used chemical coagulant in American water treatment practice since it was used in combination with the first rapid sand filter plants built around 1885. Over the years, the use of the dry crystalline form has been predominant. Alum in this form was economical and could easily be stored and satisfactorily applied through use of the available equipment.

In the late 1920's and early 1930's, however, some water treatment plants requiring large quantities of alum began to look with favor on the then relatively new "Hoover" process of making liquid alum, because it offered a saving in treatment cost. Several large cities adopted this process and installed alum manufacturing plants—among them Columbus, Ohio; Baltimore; and Washington, D.C. Because this product was not produced for the market, impurities in the form of sludge were not removed before dosing and frequent cleaning of control weir boxes and lead pipelines was necessary. It was felt, however, that the use of liquid alum offered an economical advantage that was not offset by any serious disadvantages of handling and dosing.

As the national economy has expanded and more efficient methods of chemical manufacture and transportation have come about, together with advances in equipment manufacture, the use of liquid alum in the smaller plants has come to offer possibilities of economic advantages, particularly at those installations close to alum manufacturing plants. In addition to a possible economic advantage, there is also the benefit of more efficient handling to be derived from containing the liquid in a closed system throughout its application.

It therefore appears that the present trend toward a greater use of liquid alum may be a continuing one. Its use will certainly warrant the consideration of water works officials, plant superintendents, and consulting engineers who are faced with the problem of building new facilities and renovating old plants, or who are ever searching for new ways to reduce constantly mounting plant costs.

Richard W. Ockershausen—

Tech. Service, General Chemical Div., Allied Chemical & Dye Corp., New York, N.Y.

Water filtration plants have been feeding aluminum sulfate in solution form since the incorporation of coagulation in the water purification process. Feeding has been accomplished by dissolving the dry material, which is usually ground or in lump form. Commercial liquid alum which made its appearance approximately 20 years ago, has not changed the coagulation process, although the methods of handling and feeding do differ from those used for dry alum.

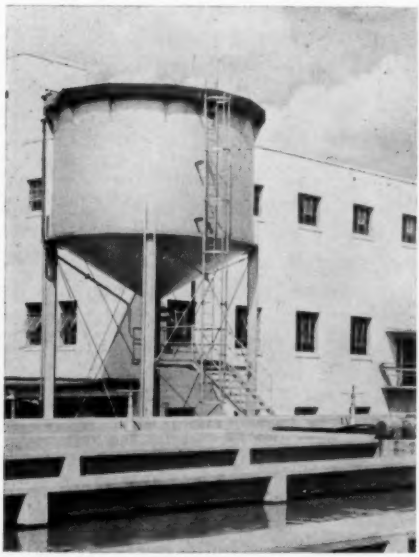

Fig. 1. Typical Liquid Alum Storage Installation

The questions most frequently asked about liquid alum are those on availability, strength, method of shipment, materials for piping; types of valves, pumps, and storage tanks used; and methods of feeding.

Availability

Liquid alum is available from numerous producers from more than 35 plants, located where relatively large demand exists. The large quantity used by paper mills has resulted in the erection of liquid alum plants in their vicinity. The plants are found in the East and Southeast, and in the North Central, Central, and South Central States, as well as in the Pacific Northwest. Many water works in these sections have converted to liquid alum. The deciding factor in determining whether there is an economy in converting to liquid alum usually is the distance from consumer to producing plant and the freight charges between these points. Although liquid alum is shipped more than 100 miles in certain sections, the freight charges on the additional pounds of water quickly offset any savings; every location requires a separate economic study.

Strength

Liquid alum is shipped at approximately 8.3 per cent aluminum oxide (Al_2O_3) content which is the equivalent of 48.8 per cent dry aluminum sulfate. A US gallon of liquid alum weighs approximately 11.15 lb, and contains the equivalent of 5.4 lb of dry aluminum sulfate.

Manner of Delivery

The greater volume of liquid alum requires shipment in stainless-steel or rubber-lined tank trucks, which hold 2,000–4,000 gal. Trucks usually are equipped with unloading pumps or compressors. In some areas, shipment is by rubber-lined railroad tank cars of 8,000–10,000-gal capacity.

Materials Needed

Piping can be of lead, rubber, polyvinyl chloride, Type FA-20, stainless

steel, or steel lined with rubber or plastic. Vales are satisfactory when made of nickel base alloy * or when of the rubber-lined diaphragm type.† Pumps for transferring liquid alum are the centrifugal type, made of nickel base alloy. Storage tanks offer some latitude in their selection; they may be of wood, concrete, or steel—all lead lined (Fig. 1). Rubber-lined steel tanks have given excellent service for nearly 20 years. A number of cypress wood tanks, without lining, have been in use for several years and will be carefully watched in view of some early installations where lead lining was later necessary. The type of wood and method of fabrication are important. One rigid, self-supporting plastic tank of 6,000 gal has been installed recently and the effect of temperature changes will be closely studied, because liquid alum is often shipped warm. Plastics are resistant to liquid alum and, where linings have been attempted, the bonding of the lining to the tank wall has been more of a problem than the inertness of the plastic. Bags of laminated plastic, 30 mils thick, in capacities up to 50,000 gal, have had about 5 years of use in the liquid fertilizer field. They may have applications in the lining of existing tanks or restoration of leaking tanks to service. One such study is in progress.

Storage tanks in northern climates should be indoors and, if placement must be outdoors, tanks should be protected or insulated from prolonged freezing conditions; southern locations offer no problem. Reference works give crystallizing temperatures of 0–18°F for 8.3 per cent Al_2O_3 liquid alum (Fig. 2). The broadness of this range arises from the difficulty of determining such data in the laboratory. As a practical matter it is desirable to keep liquid alum in tanks and feed lines at a temperature higher than 40°F. Liquid alum is shipped warm and, in view of the large volumes involved, temperatures in the crystallizing range are not usually encountered.

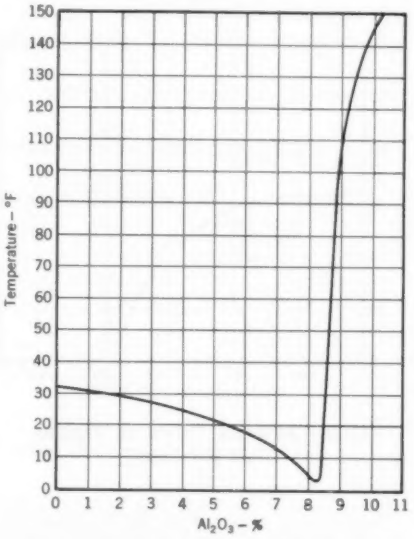

Fig. 2. Crystallization Temperatures of Liquid Alum Solutions

Feeding

A variety of devices has been giving accurate results in the feeding of liquid alum. The most common are the rotary dip feeder,* the rotameter, the proportioning pump, and the orifice box.

The manufacturers of liquid alum are able to supply considerable detailed information not given in this article.

* Such as Duriron, a product of Duriron Co., Dayton, Ohio, or Aloyco-20, made by Alloy Steel Products Co., Camden, N.J.

† Such as the Saunders Patent type by Hills-McCanna Co., Chicago, Ill., or Grinnell-Saunders, Grinnell Co., Inc., Providence, R.I. Others by B. F. Goodrich Co., Akron, Ohio.

* Rotodip solution feeder, manufactured by Omega Machine Co., Providence, R.I.

David Lurie

Tech. Director, Heavy Chemicals Dept., American Cyanamid Co., New York, N.Y.

Although the idea of introducing alum into water in liquid form is not new, the idea of manufacturing and shipping to the water works a strong solution of aluminum sulfate is certainly a radical departure from the old way of producing and shipping the dry product only.

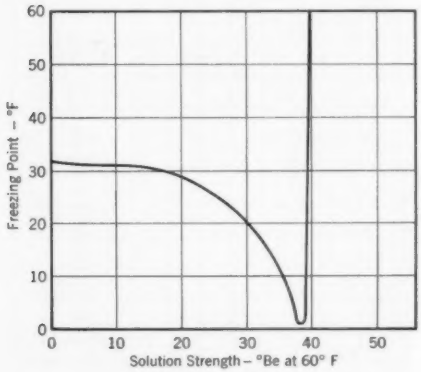

Fig. 3. Freezing Points of Various Alum Solutions

Some time ago, while the building of an alum plant was being considered, the realization was reached that the manufacturers and water works users of alum seem to be working at cross purposes. On one hand, the manufacturers go to the expense and effort of evaporating the alum solution and grinding and packing the dry material; on the other, the water works spend money and effort to undo everything and convert the dry alum to a liquid state.

Liquid alum has been available since 1939. The intervening World War II and later Korean War interfered somewhat with the growth of its use because of the scarcity of tank cars, tank trucks, and materials needed for construction of the equipment required to handle this material.

It is only within quite recent years that liquid alum has established a toehold in the water treatment field. Its use is becoming more widespread as time goes on.

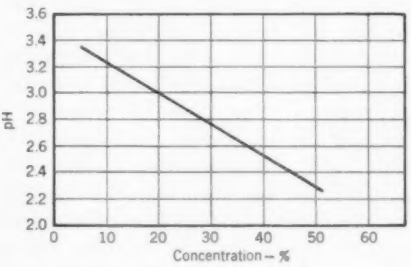

Fig. 4. pH of Alum Solutions

Characteristics

A typical analysis of liquid alum * shows the following percentages of components:

Al_2O_3, combined	8.05
Al_2O_3, excess	0.25
Al_2O_3, total	8.30
SO_3	19.50
Fe_2O_3	0.20
Insoluble matter	0.02

The freezing or crystallization point of the liquid alum analyzed, as shipped, is approximately 10°F. Figure 3 indicates the freezing points of various strength solutions. The pH of alum solutions of various strengths is shown in Fig. 4. The pH of liquid alum as shipped is approximately 2.3.

* The alum analyzed was a product of American Cyanamid Co., New York, N.Y.

Some of the advantages of liquid alum over the dry material are:

1. Lower material costs (depending on the freight rates)
2. Lower cost of unloading, storing, and handling the material
3. Simpler, more accurate feeding devices (These are easily regulated and require less maintenance than most dry feeders.)
4. Less floor storage space required
5. Rapid dispersion of the material in the raw water, because the alum is already in solution.

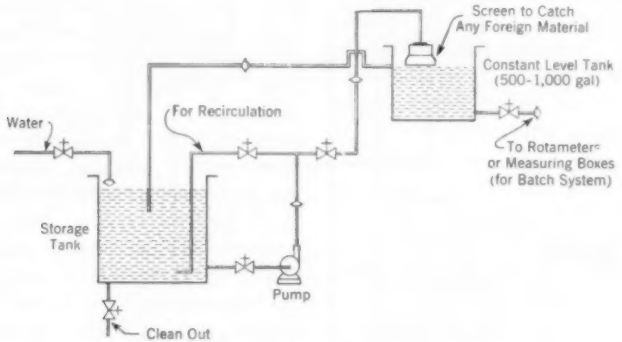

Fig. 5. Typical Feeding System

These advantages often justify the installation of equipment for the feeding of liquid alum, because the equipment can frequently be paid for in less than 3 years out of the savings achieved by its use.

Equipment Required

The basic equipment required in a liquid alum installation is a storage tank, a feeding system, and associated lines and valves. The proper choice of material for construction is extremely important.

Storage tanks are most often constructed of steel lined with lead or rubber. The steelwork for the tanks is ordinarily $\frac{5}{16}$ in. The lining is of 8-lb sheet lead or $\frac{3}{16}$-in. soft rubber. Type 316 stainless steel is acceptable for applications where linings are undesirable, but the cost of tanks constructed of this material is quite high.

In some installations concrete or wooden tanks will already be available. They can be made serviceable for the storage of liquid alum by lining them with either lead or rubber.

Unlined wooden tanks are used for liquid alum by some water works. This type of storage tank is less expensive than others, but has a tendency to leak and usually requires a good deal of maintenance. One plant has recently installed a polyvinyl chloride liner, in the form of a loose-fitting bag, in a leaking wooden tank and has reported satisfactory results so far. Polyester resin * reinforced with fiber glass can also be used for tanks.

Other lining materials which have recently been used successfully in place of rubber or lead are various vinyl plas-

* Such as Laminac, a product of Plastics and Resins Div., American Cyanamid Co., New York, N.Y.

tic coatings some of which are sprayed on and then baked, and others of which are applied in sheet form. A number of other new lining materials are being tested for this application with the aim of finding one which is lower in cost.

Proportioning pumps, rotameters, and paddle wheel-type feeders are the usual devices employed for controlling the feed of liquid alum. Orifice meters are used at Milwaukee.

A typical feeding system for liquid alum is shown in Fig. 5. This involves a constant level tank and a recirculation system and would be used with a rotameter. A similar system employing a float switch—eliminating the recirculation—has been used successfully. The rotameters employed are constructed of either stainless steel or lead and have nickel base alloy * floats.

Proportioning pumps are most frequently used for feeding liquid alum against a pressure or where the rate of feed is low. No constant level tank is required. Type 316, stainless steel nickel base alloys, hard rubber, and various plastics such as Type 1 polyvinyl chloride, lucite acrylic resin and others † are acceptable materials of construction.

Paddle wheel feeders are excellent for systems where the rate of feed is great enough to justify their cost. Chi-

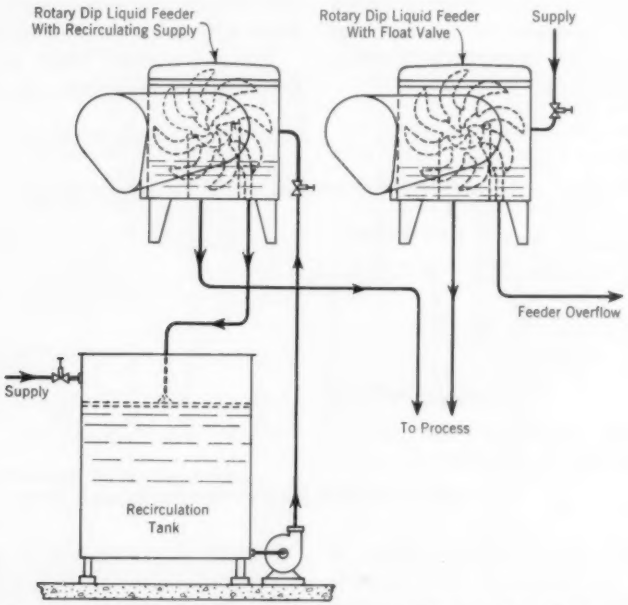

Fig. 6. Two Arrangements for Employing Rotary Dip Feeders

* Such as Hastelloy, by Haynes Stellite Div., Union Carbide and Carbon Corp., Kokomo, Ind.

† Such as Uscolite, a product of US Rubber Co., New York, N.Y.

cago employs this type of feeder. Two ways in which these devices can be arranged are shown in Fig. 6.

Various materials of construction are available. Rubber-lined steel or polyester resin reinforced with fiber glass are recommended.

All of these feeding systems can be adapted to automatic control so that the feed rate of the alum will be adjusted automatically according to the rate of flow of water through the plant, its pH, or both.

Other Apparatus

Lines leading into the storage tank are usually 2–3-in. diameter and other lines in the system ¾–1.5 in. Steel lined with lead, rubber, or plastics * and stainless Type 316 are the materials most often employed. All-lead lines are sometimes installed, but require considerable support and, therefore, are not particularly suitable for long lines. Plastics such as the styrene-acrylonitrile-butadiene copolymer blends and Type 1 polyvinyl chloride are also excellent materials but have temperature limitations which must be taken into account.

Valves can be made of the materials used for lines or of nickel base alloys.† Centrifugal pumps for use in the unloading operation or in the feeding system pictured previously usually have 1.5-in. suction pipes and 1–1.5-in. discharges. Nickel base alloys ‡ as well as hard rubber and rubber-lined steel are among the satisfactory materials.

* Such as Saran, a product of Dow Chemical Co., Midland, Mich.

† Such as Aloyco 20, manufactured by Alloy Steel Products Co., Linden, N.J.

‡ Such as Worthite, a product of Worthington Pump & Machinery Corp., Harrison, N.J., Durimet and Duriron (previously mentioned), and Hastelloy (also previously mentioned).

Conclusion

More and more water works are finding that the advantages of liquid alum justify the investment in equipment for its use. As the foregoing indicates, there are many types of equipment and construction materials which are adaptable to this application. Each water works can choose those most suitable to its operation.

James E. Kerslake

Supt. of Filtration, Milwaukee, Wis.

The principal advantage in using liquid alum is the saving in the costs of material and handling. In Milwaukee, the material saving was $3.60 a ton and the saving in handling was $2.08 a ton—a total of $5.68 a ton. Milwaukee has been using liquid alum since April 1955, and resultant savings (to Aug. 1, 1957) of $16,916.40 have more than paid the cost of the equipment—$15,544.78.

In considering the use of liquid alum, the following points must be taken into account: [1] The distance the material must be transported; [2] whether or not the solution as received needs dilution before applying; [3] the drop in temperature while the material is in transit; and [4] size, type, and arrangement of equipment for application.

Transportation

Liquid alum is transported in rubber-lined steel tank trucks of 2,000–4,000-gal capacity or in rubber-lined tank cars of 8,000–10,000-gal capacity. In colder climates the manufacturing plant should be within an 8-hr haul if the material is delivered by truck. The road into the plant should be capable of supporting the tank truck. If delivered by tank car with a haul of more

than 10 hr, the car should be insulated. It is claimed that liquid alum can be handled when the temperature of the liquid is as low as 10°F. To be on the safe side, a temperature no lower than 25°F on receipt is recommended. The temperature is between 100° and 120°F when it leaves the manufacturing plant.

Application

Liquid alum can be applied by means of an orifice box, a rotameter, a proportioning pump, or a volumetric solution feeder. If desired, the solution feeder can be mounted on scales so that the application can be controlled by determining the loss in weight per hour.

In Milwaukee the dry-feed equipment has been kept for standby service; it was used continuously from 1939, when the plant was first placed in operation, until use of liquid alum was started in April 1955.

Installation

When the equipment for handling liquid alum was installed, three stainless-steel tanks which had been a part of the dry-feed equipment were kept in service. The equipment installed included two lead-lined steel storage tanks ($9 \times 10 \times 13$), each with a capacity of 8,700 gal, two motor-driven acid-resistant pumps, three orifice boxes, and the necessary electrical control devices and piping. Plastic piping and valves were used except for a 3-in. stainless-steel pipe which conveys the liquid alum from the delivery truck to the storage tanks.

The pumps deliver the liquid alum from the storage tanks to the stainless-steel feed tanks; it then flows from the orifice boxes and lead-lined steel troughs to the point of application. The feed rate of the pump is greater than the orifice box intake so that the overflow returns to the storage tanks and produces a continuous circulation.

In Milwaukee an alum dose of 80–120 lb per million gallons is used. With the orifice box the dose can be controlled within ±5 lb per million gallons. To maintain uniformity and prevent change in level, a lead pedestal has been installed in the orifice box and the orifices are cleaned once each shift. Gages are installed on the storage tanks to measure the drop in level.

Costs

The total cost of installation, including labor, was $23,496.48. A detailed chemical analysis of the liquid alum and a table showing the cost of installation of necessary equipment is given in a previous article in the JOURNAL (*1*).

If there were no standby dry-feed equipment, larger liquid alum storage tanks would be required. Where liquid alum feeding equipment is used as the only source of feed, duplicate tanks which can hold a 30-day supply when operating at the time of maximum demand should be installed.

Reference

1. KERSLAKE, J. E. Liquid Alum at Milwaukee. *Jour. AWWA*, **49**:52 (Jan. 1957).

Oscar Gullans

Chief Water Chem. Engr., Div. of Water Purification, Bureau of Water, Chicago, Ill.

The increasing interest in the use of liquid alum as a coagulant at water purification plants prompted its experimental use at Chicago. Since the material was readily available locally, experiments were conducted in the spring of 1953 to obtain physical data for the design and construction of handling and feeding equipment. The original

equipment was installed and placed in service in August 1954.

The results in economy and ease of handling were more than gratifying. In the discussion of this handling equipment, the problems encountered, and progressive changes in equipment, a word of caution is necessary. This system is based on an annual requirement of 1,800,000 gal of liquid alum (the equivalent of 4,500 tons of dry material), or an average of 4,740 gpd. The equipment has a maximum feeding capacity of 12,000 gpd.

Shipment Methods

During the first 6 months of operation, the liquid alum was received in 10,000-gal rubber-lined cars, which were unloaded by means of compressed air. The unloading system worked very well during warm weather, but in cold weather considerable difficulty was encountered because of crystallization of materials in the car. Some of the cars were en route as long as 10 days during the extremely cold weather and, because the concentration of aluminum sulfate in the liquid was at or above the saturation point at freezing temperature it was natural for the material to crystallize. This formed a heavy mass of granular material at the bottom of the tank and clogged the unloading line. On one or two occasions unloading was made possible by use of a steam lance to free the clogged end of the discharge pipe.

Because the haul was only 39 miles from the alum plant, the contractor was able to secure a rubber-lined tank truck with a capacity of 4,000 gal for service in delivering the liquid material. For the past 2 years all liquid alum has been delivered by truck. Truck delivery has proved to be more economical than tank car, as it does not require the services of an unloading crew; the driver attaches a hose to the tank connection and the load of material is unloaded by gravity directly to the liquid alum storage tanks below. Since the truck is unloaded within a few hours after being filled, the material reaches the plant at a temperature of approximately 100°F—with no danger of crystallization.

During the first few months of operation some difficulty was encountered with crystallization of the alum in the storage tank because of a high concentration of Al_2O_3. This was overcome by the addition of a small amount of water for dilution. It was found that adding 250 gal of water for each truckload of alum (5 per cent dilution), prevented crystallization. There is some economy in having the supplier ship the warm liquid at a high concentration of Al_2O_3, which sometimes reaches 9.2 per cent. In the large storage tanks the material maintains a fairly constant temperature of 80°F. Under the above conditions the material is now delivered by the manufacturer directly to the plant tanks. In addition to saving approximately 7 per cent in the cost of the alum, there is a saving in unloading costs, for a total saving of approximately $3.80 per ton.

Storage Tanks

The present liquid alum storage system consists of two lead-lined concrete tanks with a height of 16 ft and a capacity of 40,000 gal each. The capacity of each tank is equivalent to 200,000 lb of dry alum storage. An overflow connection between the two tanks was installed at 15 ft above the tank floor. The dry alum storage consisted of fourteen elevated bins with a capacity of 100,000 lb each. Some of these are being converted to elevated liquid alum storage by lining the concrete with suitable material and adapting the bottom

hopper opening for pipe connections. The first bins are being lined with fiber glass material. The liquid will be pumped from the lower storage tanks to elevated storage as needed. Ultimate storage capacity will be 200,000 gal. With utilization of existing tanks, very few new construction changes are required. Figure 7 is a schematic diagram of the liquid alum system.

run into the unloading line at the same time that a shipment is received, there is no evidence of stratification. There is also some continuous circulation of the liquid with alternate use of the storage tanks, and some agitation is obtained from the 20-ft drop in the unloading line from the tank truck.

There is no evidence of corrosion of the lead lining in the tanks, as the

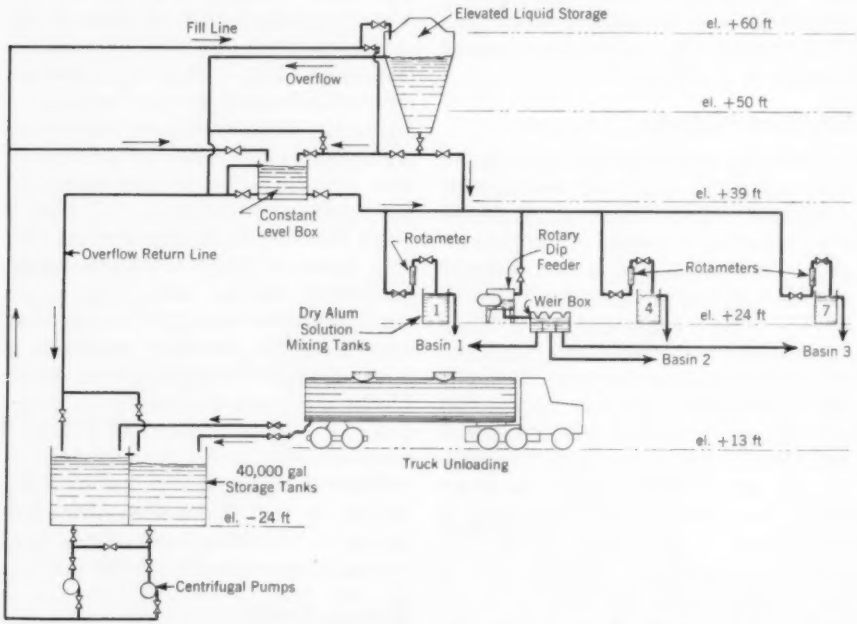

Fig. 7. Liquid Alum Handling System at South District Filtration Plant, Chicago

Because the material is diluted to keep the concentration slightly below 8 per cent Al_2O_3, the temperature can drop as low as 60°F without causing crystallization.

The iron content (Fe) in the liquid alum varies from 0.05 to 0.1 per cent and the insoluble material varies from 0.01 to 0.16 per cent. After 2½ years of operation no insoluble material has been found at the bottom of the storage tanks. Because the dilution water is lead has become coated with a thin layer of brown deposit known to be iron aluminum silicate. No increase has been found in the heavy-metals content of the stored material.

Pumps

The liquid is pumped from the main receiving and storage tanks to a constant level tank on the upper floor of the chemical building or to the elevated storage tanks as required. Two pumps

are in service, each with a capacity of 27 gpm against a 65-ft head. These are standard centrifugal pumps for chemical service, made of a nickel base alloy * and designed for continuous operation. They are operated alternately with a pumpage rate set to supply an excess of liquid alum to the constant level tank. From there, the excess flows back to the storage tank through an overflow return line. After 32 months operation, during which time it is estimated each pump has handled over 20 mil gal of the liquid, there is no appreciable wear on the pump impellers. The pumps would be operated for shorter periods when the elevated storage tanks are used.

Piping and Valves

After a considerable study of suitable piping materials, it was decided to use Type 316 stainless-steel pipe from the storage tanks to the feeding equipment. The 1.5-in. piping is of welded joint construction, except at valves and pumps, where standard flange connections were used. Because rotameters were considered for the initial installation, some type of constant level equipment was necessary. A liquid alum tank constructed of ¼-in. stainless-steel with a capacity of 450 gal was placed on an upper floor of the chemical building at the point nearest the storage tanks (Fig. 7). Three 1.5-in. stainless-steel feed lines were connected to this tank leading to the three rotameters installed for feeding the liquid alum to two of the three mixing basins. A 2-in. stainless-steel overflow line leads from the constant level tank back to the storage tanks.

All valves in the original installation were purchased as chemical resistant valves. The original valves were made of nickel alloy steel * with stainless-steel discs and seats. This valve metal contained 18–20 per cent nickel, with small amounts of chromium, molybdenum, and copper. After the system was in operation for about 5 months trouble developed in some of the valves. The first indication of trouble was at the pump suction and discharge points where it became impossible to close the valves. The valves were removed and it was observed that the nickel alloy had corroded around the valve seat and liquid alum was completely bypassing the closed valve. The stainless-steel seat and disc rings were intact but were of no value because of the bypass that had developed around the seat rings. These valves were replaced by standard Type 316 stainless-steel gate valves. These valves remain in excellent condition.

Some plastic piping (rigid type, Schedule 80) is being used for connections from the elevated storage tanks to the feeding equipment and to points of application where pressures are negligible. Although there would be little danger of damage to the plastic pipe from normal pressures and temperatures, it was felt that stainless steel would be more serviceable, particularly in the event the alum was received at a temperature above 120°F or where the pumps could develop undue pressures—for example, if the discharge valve was accidentally closed while the pump was in operation.

The present piping and valves are so arranged that the liquid can be fed from either the constant level tank, the elevated storage tanks, or directly from the pumps to either the rotary dip feeder or the rotameters. The piping system has also developed the previ-

* Durimet, product of Duriron Co., Dayton, Ohio.

* Causul metal, a product of the Lunkenheimer Co., Cincinnati, Ohio.

ously mentioned thin coating of hard brown scale. There is no evidence of corrosion of the stainless steel. The manufacturer of the liquid alum advised that the cheaper grades of stainless steel (Types 304–306) are not satisfactory for liquid alum services. One advantage of the stainless steel piping is that a section can be cut out with a welding torch and a new valve or pipe connection welded in the line. to date there is no sign of wear on the rotors. Rotameter settings are made by reading the desired feed rate from calibrated curves and setting the rate accordingly. A number of calibration curves have been made to cover any variation in the concentration or specific gravity of the liquid alum. These three rotameters replaced the nine gravimetric type 1,000-lb per hour feeders (Fig. 8).

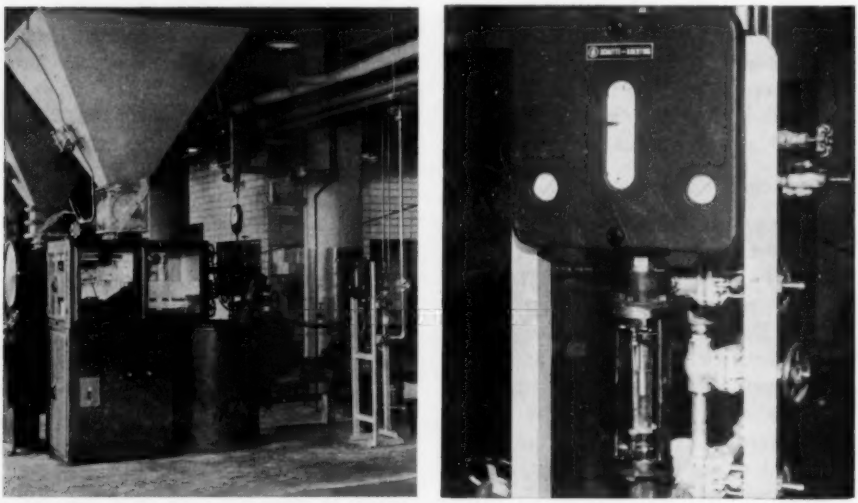

Fig. 8. Alum-feeding Equipment

At right is close view of rotameter shown with feeding equipment at left.

Feed Equipment

The original liquid alum equipment consisted of three rotameters of 0–5-gpm capacity calibrated for a liquid alum solution of 5.2 lb per gallon. Each rotameter was equipped with a needle valve for flow control, a bypass to be used during emergency periods, and a pneumatic indicator which actuated a three-pen recorder. The rotameters were made of stainless steel and

Some difficulty was noted in the rotameter system due to clogging of the needle valve and sticking of the rotor guide stem which actuated the pneumatic recorder. The clogging of the needle valve was first caused by collection of crystals of alum at this point. When the dilution system was begun, this problem was eliminated, but the clogging became progressively worse. Most of the difficulty appeared immediately after changes in the rotam-

eter setting. The rotameter would be set for the increased feed, the needle valve would gradually become clogged, but the rotor would remain at its original setting, with no visible indication of an underfeed. A hot-water flushing line was connected to the liquid system for flushing the rotameter and the supply line back to the constant level tank. This helped a little. A connection was made in order to place the needle control valve on the discharge side of the rotameter. Later, additional dilution water was added at a constant rate. This seemed to aggravate the condition, as a white crystalline deposit formed at and just beyond the needle valve.

With a routine schedule of flushing with hot water once a day, the equipment was fairly reliable. The flushing water released some air, however, which would collect at the needle valve and cause more trouble. Opening the needle valve wide for an instant as often as once every hour to flush the line was tried. This served to maintain a fairly uniform operation.

After 2 years of operation it was necessary to cut into the alum supply line to the rotameter. It was discovered that the inside of the stainless-steel pipe was coated with a light brown scale about $\frac{1}{32}$ in. thick. The surface of the coating was granular. Some loose, settled material which proved to be aluminum hydroxide and insoluble sediments was also removed. The next step was to remove the separate feed lines from the constant level tank to each rotameter and hook up all rotameters on one line to increase the velocity from an average of 0.46 fps to 1.40 fps. The loss of head in the pipe at the higher velocity was less than 1 ft per 100 ft of pipe. This improved the rotameter operation considerably by keeping the sediment in suspension, but did not entirely solve the problem. With a higher head on the feed lines, it is felt that an average velocity of 3 fps would be much better, and that a 1-in. supply line would be adequate.

An analysis of the scale formation indicated that an iron-aluminum silicate was being plated out. The same type of scale was found on the lead lining of the storage tanks and in the feed lines to the basins. The only explanation for the formation of this deposit is that, with a partial dilution of the liquid alum and subsequent cooling of the material, there may be changes in the chemical equilibrium of the small amounts of these compounds in solution, causing gradual plating out on adjacent surfaces. The type of surface seems to make no difference. It is possible that the scale was also forming on the rotameter guide stem which was responsible for the sticking that took place. Flushing the rotameter to a fully open position would temporarily relieve the condition.

Experiences at Chicago and other cities using liquid alum indicate that smaller piping for greater velocities and the least possible dilution of the liquid will give the most nearly trouble-free service. Slow formation of a white deposit of crystalline material at or immediately after the dilution point has been noted, particularly at dilutions of 100 per cent or more. This deposit appears to be a pseudo-alum of an iron or magnesium complex, not readily soluble in water, but very soluble in 10 per cent hydrochloric acid. A complete chemical analysis of this material has not been made, but the following is a rough analysis: SiO_2, 1.36 per cent; Fe, 1.03 per cent; Al, 23.3 per cent; SO_4, 31.2 per cent; Ca, none; carbonates, trace; loss on ignition, 43.6 per cent. On the other hand, the

brown deposit in the feed lines appears by analysis to be an entirely different material, consisting of a mixture of alumino silicate and ferro silicate of the following dry composition: SiO_2, 28.2 per cent; Fe, 10.7 per cent; Al, 12.1 per cent; Ca, none; SO_4, none; loss on ignition, 48.6 per cent.

New Equipment

Since the operation of the rotameters for feeding the liquid alum was not

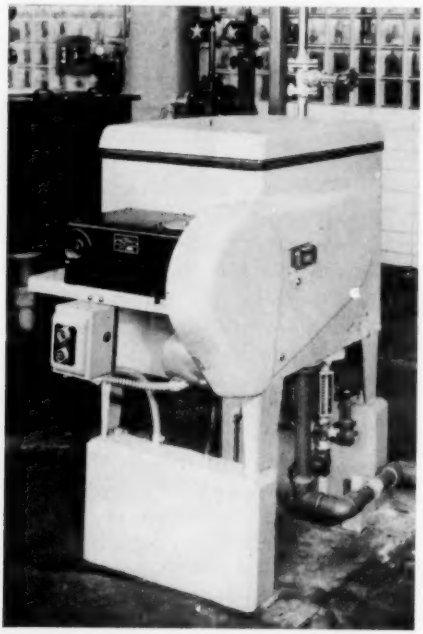

Fig. 9. Rotary Dip (Paddle Type) Feeder

completely satisfactory, consideration was given to the use of rotary dip equipment. As feeding the carbon slurry for three application points with rotary dip equipment and a single weir box, has been successful, it was decided to try this equipment for liquid alum. A single unit was installed with a small weir box made of Type 316 stainless steel for trial purposes (Fig. 9). The feed lines to the dip feeder were connected to the constant level tank. The single unit has worked so well that it has been used almost continuously for 6 months. The unit has a feeding capacity of 6–600 gph, which is well within the range of normal plant treatment. A second unit has been ordered for added capacity.

Since the rotary dip feeder is operated by a float valve, there is no small orifice to clog, and, since the unit supplies the alum for two or three basins instead of one, the higher velocity through the piping system serves to keep the lines clean. The float control on the dip feeder eliminates the necessity of the constant level tank, as the liquid alum can be drawn directly from the elevated storage tanks or supplied directly from the alum pumps. The liquid alum is diluted about 50 per cent as it enters the weir box. The weir box is constructed with baffles to give a thorough mixing of the diluted alum before it passes through the dividing V-notch weir (Fig. 10). The accuracy of the divided flows through the weirs is about 2 per cent, which is better than was expected from this simple equipment. The discharge from the weir box enters separate 2-in. lines to each mixing basin. Flushing facilities are installed for adding more water if needed. Removable screens of ¼-in. stainless-steel mesh are provided.

The simplicity of the feeder and weir box system and its efficiency of operation has solved most of the problems in feeding. Scale formation in the supply and feed lines is continuing at a slow rate. The use of additional dilution water indicates that a small amount of aluminum hydroxide is being plated out. Tests indicate that this scale can be quickly removed by running chlorine

water through the pipelines for a short period.

Another minor problem encountered with the feeder is some foaming in the float tank which does not seem to interfere with its operation. The presence has been noted of a slimy growth on the screens on the discharge side of the weir box. This was found to be a filamentous growth of "iron bacteria" known as *Sphaerotilus dichotoma,* which is related to *Leptothrix* found in acid waters, but does not require iron for growth. The temperature of 80°F seems to be ideal for growing this organism. The filamentous growth has not been found in the discharge lines to the basins, probably because of the fact that the temperature is reduced (by dilution water) below its normal growing temperature. To date it has not been troublesome, except in that it compels occasional cleaning of the screens.

The use of the dip feeder and weir box equipment leaves the rotameter arrangement for standby equipment for feeding the liquid material. Experience with the use of recording-type rotameters indicates that they do not operate too well in the low range when used with liquids like liquid alum. It is planned to install a smaller rotameter for lower feed ranges so the unit can be operated above 50 per cent of the rotameter capacity. The only explanation of why these rotameters operate best above the half-way point is that viscosity seems to have some effect. A small amount of dry alum is also kept in storage for use with the dry-feed equipment, which is operated occasionally to keep the dry-feed machines in running order. As soon as additional liquid storage is obtained by conversion of the dry-storage bins to liquid storage, most of the dry-feed equipment will be abandoned.

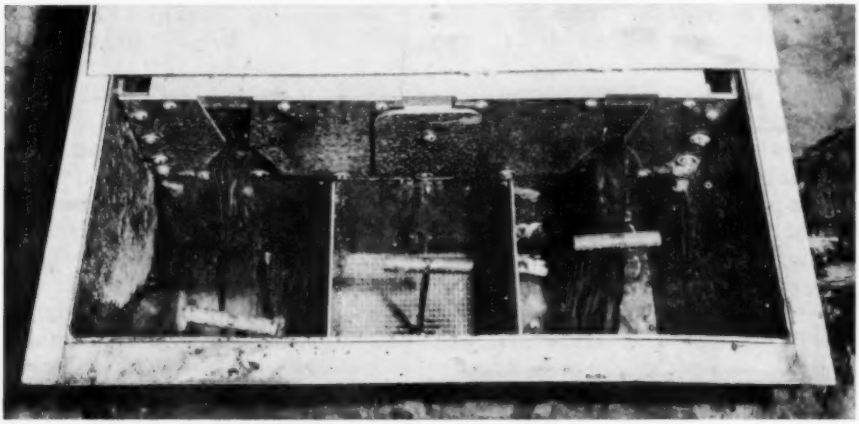

Fig. 10. Weirs Dividing Alum Flow

Conclusions

As experience is gradually gained in the handling of liquid alum, other changes probably will be made from time to time. There is no assurance that the Type 316 stainless steel will last a long time, and it may be found

necessary to try other piping materials at a later date. The difference in cost between dry alum in bulk hopper cars and liquid alum in tank trucks on the basis of dry material, plus an added saving in handling and equipment maintenance costs indicate that the new equipment will pay for itself in about 3 years of operation. The ultimate net saving will amount to about $5 per ton.

With this economy of operation it is doubtful that the dry alum feed equipment will be used for anything but emergency service as long as the liquid material is available. It is hoped that this brief account will be of some value to those who are now using or contemplating the use of liquid alum. The current trend toward the use of liquid chemicals where they are economically available offers a new challenge to the water purification field to develop simplified equipment for handling and feeding large or small quantities of such material.

Acknowledgment

The author is indebted to the technical staff of the South District Filtration Plant, Chicago, to John R. Baylis, Engineer of Water Purification, and to W. W. DeBerard, Deputy Commissioner for Water and Chief Water Engineer for their advice and assistance in the preparation of this report.

Norman E. Jackson

Engr., Camp, Dresser & McKee, Cons. Engr., Boston, Mass.

A very brief description of the principal components of alum application systems used in two installations with which the author is familiar may be of interest. These are the Dalecarlia plant at Washington, D.C., which currently manufactures the liquid alum needed in treating the water requirements of that city, and a recently built plant of moderate size at Billerica, Mass., which uses a commercially produced liquid alum for its coagulation requirements.

Components at Washington

At the Washington plant, where alum is used for clarification of an average of 165 mgd, bauxite ore containing the aluminum oxide and 60° Baume sulfuric acid are brought together in a chemical reaction which proceeds under its own heat of reaction ultimately to form liquid aluminum sulfate. This liquid is diluted in the boiling vats to a stock solution containing about 20 lb per cubic foot of 17 per cent Al_2O_3 (2.8 lb per gallon or a 28 per cent solution) and then stored in neoprene-lined steel tanks until needed. This stock solution may be even further diluted to a 10-lb per cubic foot or 15 per cent solution for more accurate metering and plant control if low turbidities and tank storage volume allow. As previously mentioned, this solution contains sludge which varies in size and amount depending on the purity of the raw materials and efficiency of the manufacturing process. For a number of years, this sludge was dosed together with the liquid alum through controlling weirs and thus disposed to the settling basins. No great problem of dosing was encountered, and routine cleaning of sludge from the weir box passages and flushing of the lead lines used in conducting the solution to the raw water was adequate.

In the existing system, plastic pipes conduct the alum from the storage tanks through a constant level box and rotameters fitted with recording and

totalizing devices to discharge into the raw water at a point of maximum turbulence in a control chamber. The rotameters, which replaced the weir method of control in 1954, were installed to obtain greater accuracy of dosing and thus better economy in the use of alum. This objective was quickly realized in the first year when they practically paid for themselves in alum savings, but they did not prove as trouble-free in operation as was hoped. This was primarily because of the tendency of sludge particles to clog the narrow passage around the rotameter float and also to the variability of the specific gravity of the alum, depending on the amount of suspended sludge present. As a consequence, routine settling of alum before application was instituted, and the problems were alleviated but not eliminated, because of the necessity of withdrawing alum from the bottom of the tanks, which entrained some sludge in the initial draw-off. In addition to operational difficulties, the presence of sludge is reflected in the inaccuracy of recording and totalizing the amounts of alum used. Accounting and inventory records are consequently adversely affected and require continuous adjustment. Rotameters have proved well adapted to the metering of a clear, uniform specific gravity liquid alum; for one containing sludge it is believed that a volumetric metering device capable of accurately metering liquids which contain suspended sludge would be better adapted.

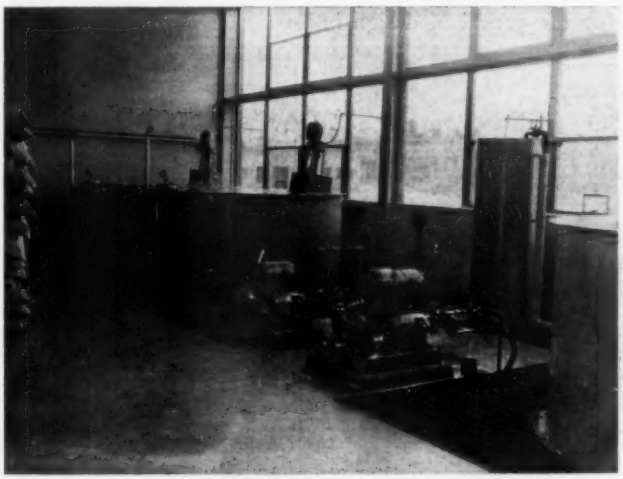

Fig. 11. Storage Tanks and Dosing Pumps

The storage tank is at the left, rear, with a dilution tank adjacent. Dosing pumps are at the center and a portion of a constant-level tank is shown at the far right.

Billerica, Mass.

Removal of iron, color, and turbidity is accomplished at the water treatment plant at Billerica through the use of liquid aluminum sulfate following free

residual chlorination. This plant, designed for 3.5 mgd and built in 1955, now treats an average of about 0.75 mgd. Alum requirements are purchased on a bid basis, with the present supplier located about 20 miles away. Clear, purified liquid aluminum sulfate of 48–50 per cent concentration based on 17 per cent Al_2O_3 (1.31 sp gr—5 lb per gallon) is delivered to the plant in 1,800-gal rubber-lined tank trucks at a present cost of about $37 per ton dry basis, fob Billerica. An analysis of cost during the period of design in 1954 showed a saving over the crystalline form of about 14 per cent based on the cost of a ton of dry alum delivered.

There have been no serious problems of transportation and delivery to the present time. The problem of freezing which might be thought to be of some consideration in the cold winters of Massachusetts is not of major importance because the distance from the manufacturer to the treatment plant is small, the dilution is such as to inhibit crystallization, and the loss of heat is prevented by the use of insulated tanks. Freezing temperature of the alum purchased is about + 17°F.

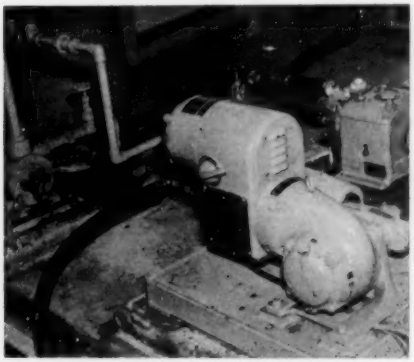

Fig. 12. Proportioning Pump

Close view of a pump shown in Fig. 11.

Transfer of the alum from the delivery tank truck to the storage tank in the treatment building is accomplished by a pump mounted on the delivery truck and a connecting hose.

The storage tank (Fig. 11), which has a volume of 2,200 gal, and which holds about a 40-day supply, is constructed of rubber-lined steel and is equipped with a rapid mixer which is used about once per day to maintain a uniform density.

The 48–50 per cent solution is pumped from the storage tank through a corrosion-resistant pump to the rubber-lined dilution tank—also of 2,200-gal capacity—in which the concentration is reduced to about 15 per cent (1.14 sp gr) by the addition of water.

It would be possible to feed the liquid alum in the concentration received, but in order to prevent settling of the alum and to provide a quick response to changes in treatment it is diluted to the 15 per cent solution and then transported by water furnished by a 10-gpm pump operating from a constant level tank (Fig. 11) to the point

Fig. 13. Point of Application of Liquid Alum

Connections to raw-water conduits are at left. View is downward into an access manhole.

of application. A positive displacement proportioning pump * (Fig. 12) regulates the dosage of the 15 per cent solution from the dilution tank to the conduit (Fig. 13) where the transport water is used to carry the dosage quickly to the point of application. Conduits for the solution are stainless-steel pipe and rubber hoses. Dosages average about 35 ppm of 17 per cent Al_2O_3. Accounting of the alum fed is accomplished by daily reading of the difference in liquid level indicated by float gages mounted in the storage and dilution tanks.

There have been no operating difficulties in the storage or application system. Crystallization has not been a problem nor has there been any difficulty due to sedimentation of any suspended particles in the 2 years that the plant has been in operation. Some spillage of alum during unloading has resulted from a faulty hose connection. Routine maintenance by the carrier should prevent occurrence of such accidental wastage. Elimination of spills of this nature within the building might be avoided by use of fill pipes extending through the building wall, provided there is no conflict with other design criteria.

* The pump used is a product of the Milton Roy Co., Philadelphia, Pa.

Summary

As the transportation of heavy chemicals by tank truck expands and as alum plants are established at convenient points throughout the country, the economic advantages of liquid alum may become obvious. This advantage, together with that of the more efficient application of a coagulant in a closed system and the lack of any serious handling and dosing problems, justifies serious consideration of liquid alum by water works officials and consulting engineers engaged in reducing operating costs, updating old plants, or building new ones.

Underground Waste Disposal and Control

Task Group Report

A report of Task Group 2450 R—Underground Waste Disposal and Control, presented on May 15, 1957, at the Annual Conference, Atlantic City, N.J., by Lynn M. Miller (Chairman), Geologist, Geological Survey Div., Dept. of Conservation, Lansing, Mich. Other members of the task group were J. G. Ferris, A. G. Fiedler, G. E. Glover, E. J. Schaefer, and S. W. Wells.

PROGRESS reports by Task Group 2450 R, covering phases of the subject of underground waste disposal and control, were published in August 1952 and December 1953 (*1, 2*). An unpublished report of subsequent progress was presented to the Water Resources Division at the 1956 Annual Conference. Even though a significant quantity of information had been added in the period from 1953 to 1956, it was not the opinion of the task group that an equitable nationwide review had been attained. Consequently, material has been added to the 1956 progress report.

In addition to the information gained by the questionnaire sent to all states in 1952, repeat questionnaires were sent out in 1955 and 1957. The purpose of this action was to perpetuate the validity of earlier work and to keep the results as current as possible. The US Geological Survey undertook, in the fall of 1955, a compilation of available data concerning instances of ground water contamination as a result of waste disposal practices. This information was collected from the USGS ground water district offices, representing 46 states and the District of Columbia.

The total information accumulated lends itself to several forms of graphic presentation. However, the most equitable, concise method appears to be a tabulation review. Table 1 represents the results of the 1957 questionnaire response, in addition to information gained from other sources and included to give full national coverage. One obvious inequality of any graphic or summary review is the comparative degree of severity to be attached to similar practices and conditions in different states. No attempt has been made to evaluate the significance of a practice or condition in any case.

Examples of Contamination

Several case histories serve to illustrate the widespread distribution and varied character of the problems and the results accruing from the disposal of wastes underground.

In certain areas in the eastern United States, particularly in Maryland and New York, serious ground water problems developed as a result of the disposal of chemical wastes. At a chemical manufacturing plant in Maryland during World War II, large quantities of acidic wastes were dumped into a nearby estuarine swamp and

the screens on wells drilled into the underlying Patuxent formation in the immediate vicinity became highly corroded in only a few months. Chemical analysis showed the ground water in this area to be highly acidic, having a pH of 3.0. Because there were relatively few wells in the area, the extent of the contamination has not been determined, but is probably confined to the aquifer underlying the immediate area. The dumping of wastes into the swamp was subsequently discontinued.

The Patuxent formation in a part of the city of Baltimore, Md., has become highly contaminated owing to the disposal of acidic wastes by local industries. Although the practice of dumping acidic wastes has not been permitted in the Baltimore area for 20 or 30 years, ground water in the Patuxent formation in the contaminated area has been rendered practically useless for most purposes. One water sample collected in the Baltimore area from the Patuxent formation had a pH of 3.60.

In Nassau and Suffolk counties, Long Island, New York, wastes from local aircraft plants were emptied into nearby leaching pits, and water samples, subsequently collected from the aquifer underlying the area, showed traces of cadmium and hexavalent chromium. When informed of the potential danger of further contaminating the ground water, the aircraft industries installed plants to treat the wastes before they were dumped into leaching pits.

Texas, which lists numerous underground disposals of brine from its oil fields, reports very few places where fresh ground water supplies have been contaminated by these waste disposal practices. Similar brine disposal practices in other states have developed extensive and critical water quality problems which are often mentioned in questionnaire response.

An Ohio industry discharges large volumes of calcium chloride wastes to the headwaters of a major stream. The volume and concentration of these wastes are such that the water supplies of downstream municipalities, which are obtained from wells in the gravel deposits along the river, are adversely affected. One city had to abandon its water supply for this reason, and the water supplies of several other municipalities are seriously affected; one of these cities is more than 100 miles downstream.

Several California municipalities have experienced pollution of ground water supplies as a result of local underground disposal practices. In Lemoncover, a small town about 60 miles southeast of Fresno, disposal of borax and boric acid solutions, used as fungicides in fruit packing plants, has led to a high boron concentration in water from nearby wells. Operation of a zeolite water softening plant about 2 miles northeast of Fresno caused substantial increase in hardness and chloride content of well water in the vicinity as a result of dumping of saturated sodium chloride solution into an unlined sump. About 14 miles east of Sacramento, manufacturing wastes were discharged into gold-dredge tailing pits. These wastes were in the form of potassium and ammonium perchlorate, constituents not found in natural ground waters. As perchlorates are toxic to plants in concentration of 1–2 ppm, they have been used as weedicides. The wastes, having concentrations of 3,500–5,000 ppm of perchlorate, appear to have affected an area of several square miles. Oil field brines, phenols,

TABLE 1

State	Types of Contaminants					Actual Contaminants
	Sewage	Oil, Gas	Chemical, Industrial	Other	None	
Alabama	x	x				
Arizona	x	x	x			sewage, fuel oil, chromic acid, phenol
Arkansas					x	
California		x	x			perchlorate, brine, boron, phenols
Colorado	x	x	x			sewage, gasoline, chlorides
Connecticut	x	x	x			sewage, fuel oil, chromium, textile degumming wastes
Delaware				x		pickle brine, sanitary fill material
Florida	x		x	x		citrus, laundry, dairy and brewery wastes; acid, wood distillates; phenol
Georgia		x				gasoline
Idaho	x		x			domestic sewage
Illinois		x	x			brine, heavy metals, cyanide, petro chemical
Indiana	x	x	x			brine, chromium, hydrocarbons
Iowa	x		x			beet sugar wastes, fluoride, calcium
Kansas	x	x	x			brines, detergents
Kentucky	x	x	x			fluorides, chlorides
Louisiana		x		x		chlorides
Maine	x		x			domestic sewage
Maryland		x	x	x		gasoline, organic cannery wastes
Massachusetts	x		x			sewage, tannery waste, organic material, chlorides
Michigan	x	x	x	x		sewage, cyanide, caustic soda, copper, phenols, chlorides, picric acid, pipeline sealer
Minnesota	x	x	x	x		sewage, stormwater drainage, gasoline, phenols, chromates, waste acid
Mississippi					x	
Missouri	x					sewage
Montana*						
Nebraska	x			x		sewage, detergents, gasoline
Nevada	x					septic tank effluents
New Hampshire					x	
New Jersey			x			chromium, manganese, iron salts, chemical wastes
New Mexico		x	x			brines, uranium mill wastes
New York	x	x	x	x		gasoline, oil, chrome, barium, fluoride, chlorides, detergents
North Carolina	x	x				gasoline, fuel oil, sewage, surface water
North Dakota	x					sewage
Ohio	x		x	x		sewage, calcium chloride, sodium chloride
Oklahoma		x				oil well brines
Oregon	x		x			pea cannery wastes calcium sulphate
Pennsylvania	x		x			sewage, industrial wastes
Rhode Island	x			x		sewage, sulfuric acid
South Carolina					x	
South Dakota	x			x		
Tennessee	x	x	x			domestic sewage, whey, gasoline
Texas		x				brine
Utah	x					sewage
Vermont	x					sewage
Virginia			x			iron, calcium, chlorides, etc.
Washington					x	
West Virginia	x	x				sewage, oil, brine
Wisconsin	x	x		x		sewage, gasoline, kerosene, processed wastes, sulfite liquor, cannery wastes
Wyoming	x	x	x			cresols, pentachlorophenol, oil, sewage

* No information available from any source.
† Use of cesspools and dumping into abandoned wells prohibited by rules and regulations of the State Department of Health.

and other industrial wastes have on several occasions caused pollution of ground water in the metropolitan Los Angeles area.

The contamination of water supplies by mine drainage might be considered beyond the scope of this paper, the subject of which is primarily underground

Response to Task Group Questionnaire

Source of Contamination							Statutory Control		
Disposal Wells	Impoundments, Lagoons	Surface Water Dumping	Abandoned Shafts	Cesspools, Septic Tanks	Ground Surface	Other	Adequate	Nonexistent	Being Formulated
x				x		sink holes	x		
x		x		x			x		
							x		
	x	x			x				
x	x			x	x	leakage of storage tanks and pipe lines	x		
	x			x			x		
		x			x	drainage from sanitary fill			
x	x				x		x		x
						accidental spills and leakage from storage tanks		x	
x				x				x	x
	x	x					x		
x	x	x					x		
	x		x	x			x†	x‡	x§
	x	x							
x	x	x		x			x		
		x					x		
	x	x	x	x			x		
					x	leakage from storage tanks	x		
	x	x			x		x		
x	x	x	x	x	x	leakage from tanks, sewers, spills	x		x
x	x		x	x	x	dumping into sink-holes			x
							x		
				x					x
	x					leakage from shallow sources	x		
				x			x		
		x			x	spoil from dredging operations			
	x	x				exploratory shot hole, potential	x		x
x	x			x		leakage of pipeline and storage tanks	x		x
				x		leakage of storage tanks	x§		
				x			x		
		x				drainage into sink-holes, leaking salt wells, buried tanks, possible repressuring operations			
x		x					x		
	x						x		
x				x			x		x
				x				x	
							x		
				x		accidental spillage	x		
x			x	x		dumping into caves	x		
	x	x			x		x	x	x
				x			x		
				x					x
					x	sink hole	x		
						‖			
x			x	x		oil well drilling wastes		x	
	x			x		dumping into gravel pits and quarries, accidental spills and leakage	x		
	x			x	x		x		

‡ Relative to waste waters other than sewage.
§ Public systems only.
‖ Irrigation with highly polluted waters presents danger to rural wells.

waste disposal. The effects of mining operations in the coal regions upon water supplies are at times, however, so serious that it is pertinent to call attention to the relationship between ground water and stream pollution. As reported by Raymond Snyder and others in August 1947 (*3*), the quality of

water in several streams in Pennsylvania, which have been used as sources of municipal water supply, has deteriorated so greatly that new sources of supply have had to be developed.

The deterioration in quality of both surface and ground waters resulted chiefly from the oxidation of iron pyrites in the coal and associated shales. The oxidation process occurs as air-saturated rain water percolates through the loosened and broken-up material in the soil banks created by coal stripping, and, under the ideal conditions thus presented, sulfuric acid is formed and calcium, magnesium, aluminum, manganese, and iron are released to contaminate the ground water. Because of the poor quality of the resulting ground water, it is not possible to develop potable water supplies from ground sources in many areas where coal mining operations have been conducted. The damage from such operations, however, is not confined to the ground water supplies alone, for ultimately the polluted ground water reaches the streams. As the low-water flow of the streams is derived from ground sources, the net effect of coal stripping operations may be to render both ground and surface water supplies within the region unfit for use.

Undoubtedly, the reported occurrences used in compiling Table 1 constitute only a small percentage of those which have actually taken place. The absence of a reported practice for any particular state does not indicate that such disposal has not taken place in that state, but rather that the practice has escaped detection or that no serious problem has developed as a result. An example of practices that may be looked upon with disapproval in the future is taking place in an Ohio city of 7,000, where all sewage is discharged through sink holes into subterranean limestone strata. Undoubtedly, the practice results in pollution of ground water. This city and other neighboring municipalities all obtain public water supplies from surface sources, however, because the ground water has objectionable chemical characteristics that make it undesirable for public supply purposes. Future developments, however, may present other uses for this ground water.

Present Study

Table 2 was compiled from a literature survey conducted as part of an investigation of travel of pollution in California (*4*). This tabulation points out the fact that pollution may travel great distances. It also indicates that inorganic chemical pollution may be much more significant than bacterial pollution in this respect. These facts are of major importance when disposal of industrial and commercial wastes is considered. The widespread use of detergents and their presence in municipal sewage plant effluents presents a similar inorganic pollutant problem.

It would be unjust to make a statistical comparison of the cases reported for the purpose of determining the most critical problems of ground water contamination. Note should be made, however, of the type of problem reported for various areas of different economic bases. One thing which is readily perceived is the fact that problems relate to increasing population activities.

A study of data published by the US Department of Commerce and the Census Bureau (Fig. 1) was conducted to determine what trends might be closely allied to ground water pollution problems. These studies did not reveal any particular correlation between existing problems and census figures. It is in-

TABLE 2

Summary of Distances of Travel of Pollution

Nature of Pollution	Pollutant	Observed Distance of Travel *ft*	Time of Travel
Sewage polluted trenches intersecting ground water	coliform bacteria	65	27 wk
	chemicals	115	
Polluted trenches intersecting ground water	coliform bacteria	232	
	uranin	450	
River water in abandoned wells	intestinal pathogens	800	17 hr
	tracer salts	800	17 hr
Sewage in bored latrines intersecting ground water	coliform bacteria	10	
	anaerobic bacteria	50	
	chemicals	300	
Sewage in bored latrines lined with fine soil	coliform bacteria	10	
Sewage in bored latrines intersecting ground water	coliform bacteria	35	
	chemicals	90	
Sewage in bored latrines intersecting ground water	coliform bacteria	80*	
Coliform organisms introduced into soil	coliform bacteria	164	37 da
Sewage effluent on percolation beds	coliform bacteria	400	
	ammonia	1,400	
Sewage effluent on percolation beds	bacteria	150	
Sewage polluted ground water	bacteria	†	
Introduced bacteria	*Serratia marcescens*	69	9 da
Chlorinated sewage	phenols, fungi	300	
	dye	300	24 hr
Industrial waste	tar residues	197	
	picric acid	‡	
Garbage leachings	misc. leachings	1,476	
Industrial wastes	picric acid	15,840	4–6 yr
Industrial wastes in cooling ponds	Mn, Fe, hardness	2,000	
Garbage leachings	misc. leachings	2,000	
Garbage reduction plant	Ca, Mg, CO_2	500	
River water	Fe, misc. chemicals	164	
Chemical waste	misc. chemicals	§	
Industrial wastes	chromate	1,000	3 yr
	phenol	1,800	
	phenol	150	
Salt	chlorides	230	
Oil field brine	chlorides	1,300	
Salt	chlorides	200	24 hr
Gasoline	gasoline	10,560	
Weed killer wastes	chemical	105,600	6 mo
Radioactive rubidium chloride	radioactivity		5 da

* Regressed to 20 ft.
† A few feet.
‡ Several miles.
§ From 3 to 5 miles.

teresting to note, however, that Fig. 1 indicates two general rates of increase in industrial activity, one of which is nearly three times greater than the other. As might be expected, the greatest general activity is in the states surrounding the Great Lakes and those directly east of the lakes. Some of the

most severe cases of ground water contamination have occurred in these areas.

The inequality of consideration given to making reports may, in part, account for the lack of correlative patterns of industrial growth and disposal practices. Other factors, however, must be given due consideration. Major sources of water supplies, generally geologic controls governing the movement of ground water, and the readiness of public utilities adequately to support industrial expansion complicate the evaluation. Considering these factors, a surprising number of states expressed a feeling that present statutes provided adequate controls.

In only a few areas do political boundaries coincide with ground water divisons on major drainage areas. It must be assumed, then, that the potential variety of problems facing most states is boundless, and that, to be adequate, statutory controls must be very broad and have multiple interpretations or be augmented continuously.

It is evident that underground pollution is a national problem and many states have a wide range of contamination problems. But, it is further evident that the factors which determine pollution potentials and the proper degree of concern are so variable that area comparisons on a national scale are unjust. It would be difficult, if not impossible, to apply a standardized set of waste disposal principles to the wide range of geologic, hydrologic, economic, industrial, and population variables which occur throughout the United States. Because of these variables, a great degree of intimacy with the area being studied is required for an accurate cause-and-effect study of waste disposal practices.

Future Study

The soundest approach to future study appears to be on some unified basis. Under such a system, states

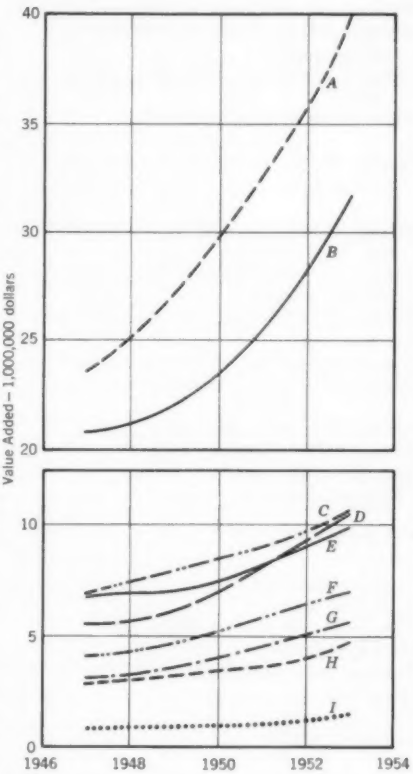

Fig. 1. Increase in Industrial Activity

Figures are based on a study by the US Department of Commerce. Regions are indicated by the following curves: A, *East North Central;* B, *Middle Atlantic;* C, *South Atlantic;* D, *Pacific;* E, *New England;* F, *West North Central;* G, *West South Central;* H, *East South Central; and* I, *Mountain States. Added values are approximate gains from manufacture, derived by determining total values of products shipped and subtracting costs for materials, supplies, and so forth.*

with similar control characteristics could be grouped for study of common existing problems and determinations of the trends being established in their areas. It would be necessary for some states to work with two or more groups because of the variety of control conditions in their regions. The accomplishments of such study groups would facilitate the forecasting of legislative and utility needs before critical conditions evolved.

To estimate properly the ground water pollution potential for any area, it is necessary for the appraisers to be fully informed and capable of assigning proper importance to several factors:

1. The rate of industrial growth and the adequacy of waste disposal facilities which are existent or can be created to handle the growth
2. The expansion of urban or suburban developments attendant to industrial expansion
3. The available water sources and comparative use of waters from different sources
4. The general geologic and hydrologic conditions which will govern the movement of contaminants if they do enter the ground
5. A knowledge of the existing statutory controls over waste disposal practices.

The findings and recommendations of regional study groups would be applicable without alteration in their own backyards, thereby increasing the value of their efforts well above those expended by national survey groups. The proper future role of AWWA Task Group 2450 R appears to be that of a clearing house or coordinating group for regional study groups.

The following incomplete bibliography (*1–21*) lists several reports on the contamination of ground water by underground waste disposal where the problem has been so extensive or the conditions so severe that systematic investigations were undertaken. A careful reading of these reports shows clearly that valuable ground water supplies, once contaminated by the wastes resulting from modern civilization, which is based so fully on industrial development, are rendered useless for extended periods, if not indefinitely. With the marked increase in the use of water throughout the nation, it is obvious that sources of potable water must be protected so that the economic growth of the country will not be retarded. Though underground waste disposal has not yet become a serious problem in many sections of the country, nevertheless it is a growing problem which in many places is critical enough to warrant further careful and systematic study.

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Carbonation of Water Softening Plant Sludge

F. A. Eidsness and A. P. Black

A paper presented on May 14, 1957, at the Annual Conference, Atlantic City, N.J., by F. A. Eidsness, Vice-Pres., and A. P. Black, Pres., Black & Assocs., Inc., Gainesville, Fla.

RECALCINATION of water softening plant sludge is a process in which the sludge, concentrated to 60–65 per cent solids, is burned at 2,000°F, the calcium carbonate and magnesium hydroxide present being converted to the corresponding oxides.

Primarily because of the increasing problems of sludge disposal from municipal lime softening plants, recalcination is being seriously considered by the water works industry. The calcining plants at Miami, Fla., and Lansing, Mich., are operating successfully and plants are under construction at Dayton, Ohio, and Gainesville, Fla.

A major problem of recalcination is the large quantity of magnesium in the softening-plant sludge. At Miami, the magnesium content of the sludge is only 1.8 per cent, but the sludge produced by softening most natural waters has a considerably higher content. The reduction of magnesium in the sludge has heretofore been obtained by either the Hoover process (*1*), in which calcium carbonate is selectively precipitated, or by the Lykken-Estabrook process (*2*), in which, in the first of two stages, 12 per cent of the throughput of the plant is treated with the total lime requirements, with the resultant sludge (containing that portion of the magnesium precipitated from the water and all that present in the recycled lime) being rejected. Sheen and Lammers (*3*), found that centrifuging at 1,000 times gravity rejected approximately 50 per cent of the insolubles and magnesium. It must be borne in mind, however, that since the recalcined lime is reused in the softening process, a gradual buildup of magnesium will occur.

The percentage and physical character of the suspended solids are the factors determining sludge volume. Studies by Nelson (*4*) and experiences of the writers indicate that the physical characteristics of water plant softening sludge vary widely. The concentration of sludge from softening basins may vary 2–18 per cent by weight, depending upon the time and method of concentration in the softening process, the coagulant used, and the calcium-magnesium ratio of the raw water. More important than the percentage by weight of the solids in the sludge is the volume occupied by these solids. Black (*5*) has shown that the increased magnesium content of the sludge decreases its settleability and increases the sludge volume.

In the recalcining operation prior to centrifuging, the sludge in the softening tanks is first thickened to approximately 20 per cent by weight in a conventional sludge thickener. This is necessary in order economically to ob-

tain the required yield of solids in the cake from the centrifuging operation. Increasing amounts of bulky, gelatinous magnesium hydroxide require a corresponding increase in area and volume of the thickener tank.

A reduction of magnesium in the softening plant sludge would result in better sludge settling characteristics, higher sludge solids concentration, and a lime of higher calcium oxide content.

Nelson (*4*), in his work at the water softening plant in Findley, Ohio, found that the carbonation of softening-plant sludge prior to centrifuging reduces the magnesium content. With this magnesium reduction, a constant percentage of solids in the centrifuge cake is obtained at variable feed rates. The carbonation, however, was not carried out under controlled conditions, the carbon dioxide being distributed through lawn sprayers into the sludge for a period of 3.5 hr. It is generally assumed that for 1 lb of commercial quicklime added there is an average yield of 2.5 lb of calcium carbonate sludge (dry basis). Since each pound-mole of calcium carbonate burned in the recalcination process produces an equal amount of carbon dioxide, it is quite obvious that ample gas is normally available for converting all of the insoluble magnesium hydroxide present in the sludge to the soluble bicarbonate. There are, therefore, a number of problems to be solved in connection with the successful and economical carbonation of water softening sludge. These involve determination of: [1] the percentage conversion of insoluble magnesium hydroxide to soluble magnesium bicarbonate at varying mole ratios of carbon dioxide to magnesium oxide; [2] the effect of retention time when other factors are held constant; [3] the amount of calcium carbonate which would be dissolved under the conditions studied; and [4] the improvement of sludge settleability and concentration. Only after these four factors have been quantitatively evaluated can the economics of the process be determined.

Experimental Procedure

All analytical determinations were made in accordance with *Standard Methods* (*6*) with the exception of a modification of the ethylenediamine tetraacetic acid (EDTA) method. It was found that standardized EDTA solutions several times more concentrated than normally used would yield data of sufficient accuracy for this study. By use of the standard EDTA method, the calcium and magnesium concentrations of the raw sludge supernatant were determined. After carbonation, the supernatant of the sludge was filtered through Whatman No. 40 filter paper and a 50-ml aliquot of the filtered supernatant titrated with EDTA solution, of which 1 ml equals 10 mg combined calcium and magnesium as calcium carbonate. Another 50-ml aliquot was titrated with standard EDTA solution for the determination of the calcium concentration; the magnesium concentration is the difference. The percentage of magnesium removal is determined as follows:

$$\frac{\text{Magnesium in supernatant of carbonated sludge} - \text{Magnesium in supernatant of raw sludge}}{\text{Magnesium in raw sludge}} \times 100$$

Magnesium removal studies were made both on a laboratory and pilot plant scale. In the laboratory study, samples of raw sludge of known concentration were introduced into a cylinder 3.4 cm in diameter and containing a porous glass diffuser plate. Air–carbon dioxide mixtures varying from

10 to 33 per cent carbon dioxide by volume were introduced into 200-ml samples of raw sludge. The theoretical required volume of carbon dioxide for each experiment at 25°C and 1 atmosphere pressure was calculated from the concentration of magnesium in the raw sludge.

The first experiments were designed to determine the effect of time of carbonation, with all other variables constant. At Gainesville, sludge contained 4.0 per cent solids by weight, of which 3.13 per cent (dry basis) was magnesium oxide; the Dayton sludge contained 3.2 per cent solids by weight, of which 3.33 per cent (dry basis) was magnesium oxide. Throughout these experiments, the mole ratio of carbon dioxide to magnesium oxide was held at 3:1, or 1.5 times the theoretical requirement based on the conversion of all of the magnesium oxide to the bicarbonate. Figure 1 shows the results of duplicate runs for five different carbonation times on Gainesville sludge which varied from 5 to 20 min and of duplicate runs of five different carbonation times on Dayton sludge which varied from 3 to 30 min. The data indicate that conversion of the magnesium hydroxide to the soluble bicarbonate is very rapid, about 96 per cent of that removed from both the Gainesville and the Dayton sludges having been dissolved in the first 15 min.

The amount of magnesium oxide dissolved from the Gainesville sludge is somewhat less than that dissolved from the Dayton sludge, of approximately equal solids content, in any given time period. This may be because, at Gainesville, aluminum sulfate, which is fed as a coagulant, would have the effect of substantially increasing particle size, whereas at Dayton, no coagulant is used. Measurements of particle size of Dayton sludge indicated that particle size averaged 3–4 μ.

In the second experiment, fresh sludge from the Gainesville softening plant was carbonated while varying both carbonation time and the mole ratio of carbon dioxide to magnesium oxide. The data from these tests are

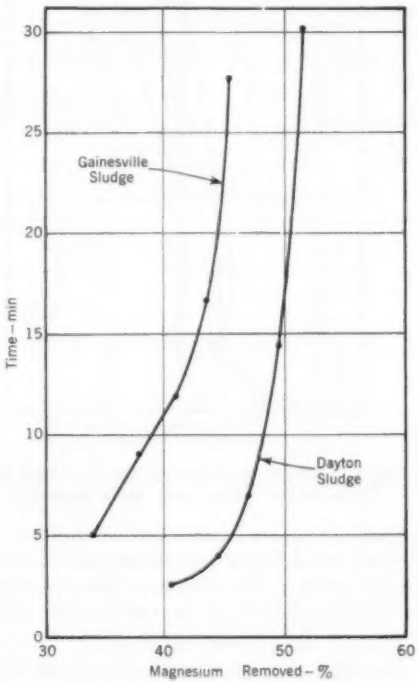

Fig. 1. Effect of Time on Carbonation of Sludge

presented in Fig. 2. Carbonation times varied from 3.5 to 30 min and mole ratio ranged from 1:1 to 10:1. The curves show that, in general, increasing the ratio of carbon dioxide to magnesium oxide exerts relatively little effect in converting magnesium oxide to the soluble bicarbonate. For example, for a 30-min carbonation period, 45 per cent of the magnesium oxide present is

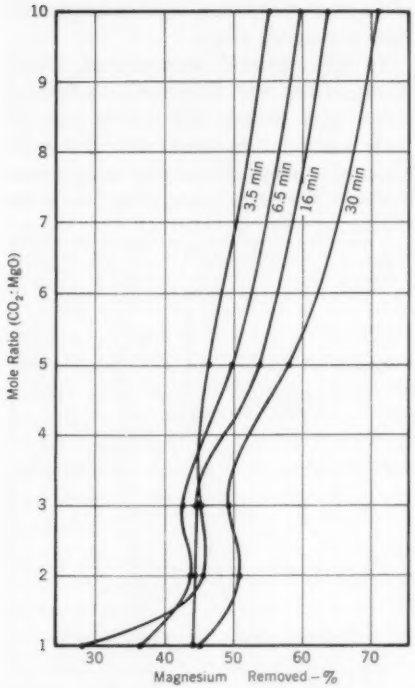

Fig. 2. Effect on Carbonation of Varying Carbonation Times and Mole Ratios

Raw sludge used contained 2.5 per cent solids and 3.54 per cent magnesium oxide (dry basis). The volume of the gas was 2 liters and that of the sample, 200 ml.

dissolved at a mole ratio of 1:1, or 50 per cent of theoretical demand, whereas only 61 per cent is dissolved at a mole ratio of 10:1—or five times theoretical demand.

Pilot Plant Studies

With the recognition that the laboratory experiments closely approximate maximum carbonation efficiency, a pilot plant was constructed adjacent to the solids contact softening basin of the Gainesville water plant in order to secure data under actual operating conditions. The carbonation tank had a volume of 500 gal, a water depth of 4.2 ft, and an area of 20 sq ft. The manifold for introducing the carbon dioxide mixture consisted of four 2-in. pipes, each 4 ft long, with 0.25-in. orifices drilled on 3-in. centers. The gas for carbonation, obtained from the stack breeching of the power plant, was scrubbed and compressed and measured into the carbonation tank through a rotameter. The rate of flow of sludge in each experiment was calculated from the time required to fill a 10-gal bucket with carbonation basin effluent. An Orsat test for carbon dioxide was made on the stack hourly during the pilot plant experiments. The per cent by volume of carbon dioxide was quite uniform, varying from 10.8 to 11.2. An average value of 11 per cent of carbon dioxide by volume was used for all calculations. In each experiment,

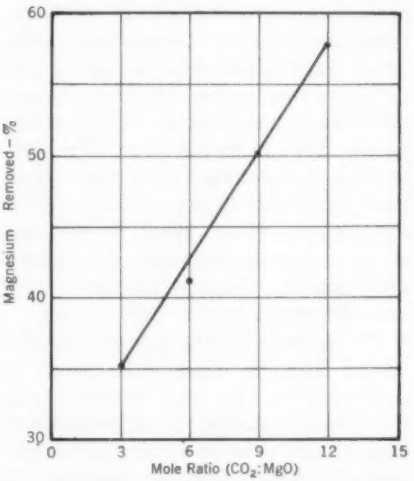

Fig. 3. Effect of Mole Ratio on Removal of Magnesium Oxide

Raw sludge used contained 2.55 per cent solids and 3.20 per cent magnesium oxide (dry basis). Retention time was 30 min.

100-ml aliquots of both raw and carbonated sludge were collected each 5 min for a period of 1 hour. If the retention time for the experiment was 30 min, collection of raw samples preceded that of the carbonated sludge by the retention time period. Aliquots of both raw and carbonated sludge so collected were composited, and the required analytical tests run.

Figure 3 shows the results of the first pilot plant run in which the mole ratio of carbon dioxide to magnesium oxide was the variable. The diffuser was installed 4 ft below the water surface.

The inaccuracy of the flowmeter at low gas flows set the minimum mole ratio at approximately 3:1 and the size of the compressor established a maximum. Figure 3 shows that between these ratios the relationship between the mole ratio and the percentage of magnesium oxide removed is linear. As shown in Fig. 2, in laboratory runs the relationship between the limiting values is also approximately linear, although that is not true for mole ratios below 3:1.

TABLE 1

Typical Concentrations of Raw and Carbonated Sludge in Carbonation Basins *

Run No.	Magnesium in Sludge—*mg/l*	% by Volume (60 min Settling)
	Raw Sludge	
1	841	75.5
2	716	64.5
3	403	29.0
4	347	26.0
5	418	38.0
6	463	55.5
7	539	57.0
	Carbonated Sludge	
1	659	30.5
2	566	26.0
3	202	13.0
4	201	13.0
5	201	12.0
6	279	19.0
7	289	17.7

* Study made at Gainesville, Fla.

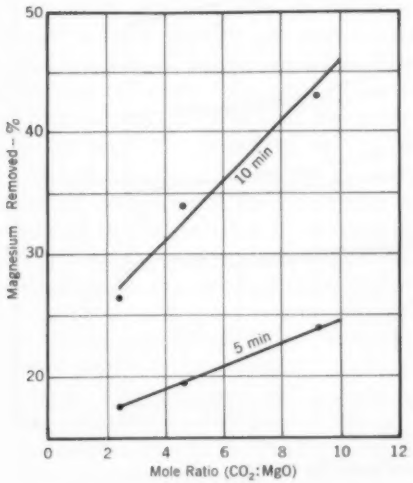

Fig. 4. Results of Carbonation at Low Retention Times

Comparison of Fig. 2 and 3 also shows that percentage removal of magnesium oxide was not as good in the pilot plant as in the laboratory experiments. This is believed to be due to the fact that in the laboratory diffuser the gas bubbles were many times smaller than in the pilot plant. There is no reason why percentage removal of magnesium oxide equal to that found in the laboratory could not be obtained in actual practice when more efficient diffusion of gas into the sludge is provided.

In order to carbonate the sludge at various mole ratios for low retention periods, the carbonation tank was modified. This was required because of the limited compressor capacity.

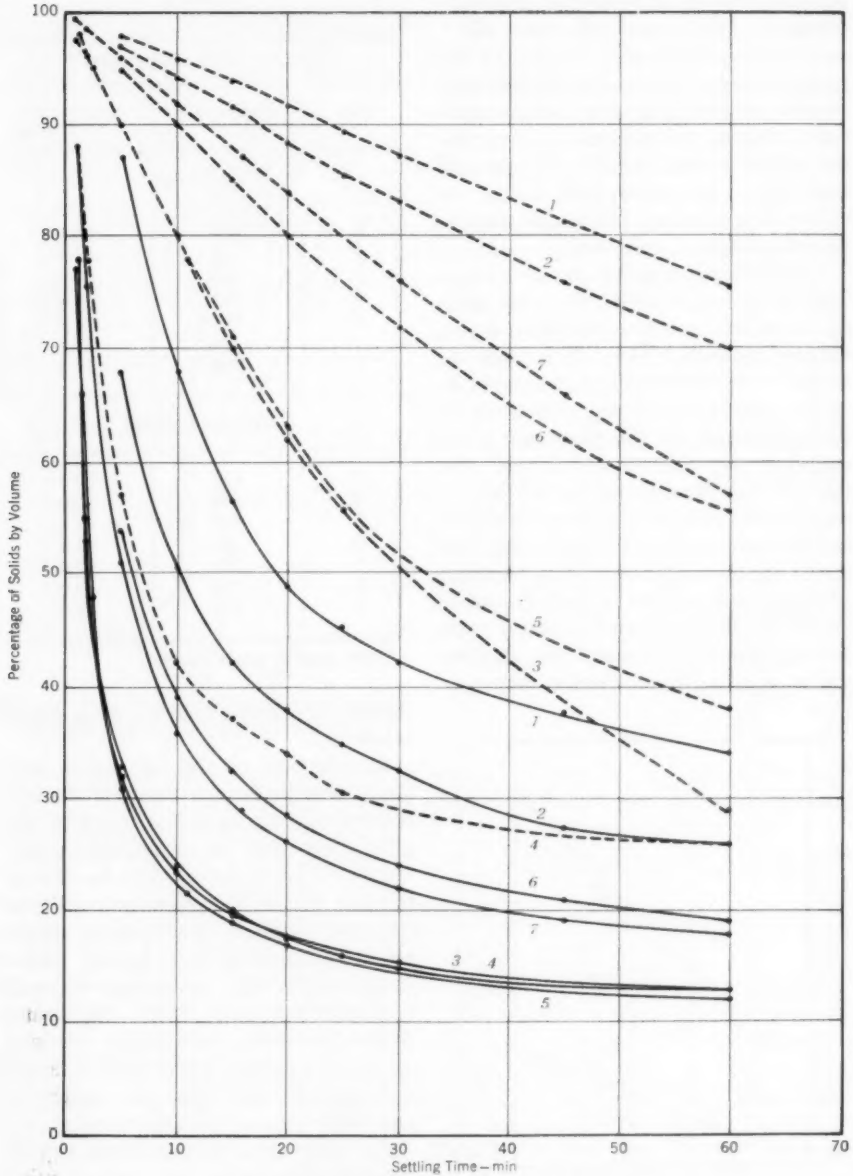

Fig. 5. Results of Settleability Tests

Dashed curves are for raw sludge, solid for carbonated sludge. Italic numerals are run numbers.

The revision consisted of filling the tank to half its volume with river gravel. The carbon dioxide manifold was raised to within 2 ft of the liquid surface. The mole ratio was between 2.2 and 9.6 and the retention time between 7.5 and 15 min. The data obtained from these tests are presented in Fig. 4 and show that percentage removal is approximately linear between the limiting mole ratios. Comparison of Fig. 3 and 4 shows that at any specific mole ratio, the percentage of magnesium removal decreases with retention time.

Settleability Tests

As previously stated, the settleability of the raw sludge is a function of the percentage of solids by weight, the magnesium content, and the coagulant used in the softening process. Tests were conducted to determine the percentage by volume occupied by the raw and carbonated sludge. These experiments were carried out in the carbonation basin at Gainesville at its maximum volume of 500 gal and a grid depth of 4 ft. The concentration of the raw and carbonated sludge is shown in Table 1 and the results of the settleability tests are presented in Fig. 5.

These data indicate that the carbonation of sludge, with the conversion of part of the magnesium to the soluble bicarbonate, greatly reduces the volume occupied by the solids. It is evident from the data that the volume occupied by the solids in either the raw or carbonated sludge at the end of any period of settling depends upon the amount of magnesium hydroxide present, the volume decreasing with decreasing amounts of magnesium hydroxide. The effect is not so noticeable, however, in sludges of low solids content but it is to be noted that such sludges are not ordinarily obtained in the operation of lime or lime-soda softening plants.

The curves also indicate that maximum settling takes place and minimum sludge volumes are obtained in a relatively short time in carbonated sludges, whereas much longer times are required for raw sludges. These data made it possible to reduce the diameter of the thickener to be used at Dayton from 167 ft to 132 ft, or from an effective area of 21,000 sq ft to 13,000 sq ft.

TABLE 2

Quantities of Calcium Carbonate Dissolved Under Various Laboratory Conditions *

Carbonation Time—*min*	Mole Ratio (CO_2:MgO)	Calcium as $CaCO_3$ in Supernatant Carbonated Sludge—*mg/l*
3.5	1:1	90
3.5	2:1	89
3.5	3:1	83
3.5	5:1	86
3.5	10:1	86
		Avg: 87
6.5	1:1	76
6.5	2:1	116
6.5	3:1	86
6.5	5:1	84
6.5	10:1	84
		Avg: 89
16	1:1	83
16	2:1	106
16	3:1	108
16	5:1	86
16	10:1	82
		Avg: 93
30	1:1	100
30	2:1	102
30	3:1	96
30	5:1	101
30	10:1	114
		Avg: 103

* Calcium carbonate in raw sludge: 34 mg/l.

Calcium Carbonate Removal

Table 2 shows the amount of calcium carbonate dissolved during laboratory experiments with Gainesville sludge. The mole ratio was varied from 1:1 to 10:1, or from half to five times theoretical values. Carbonation times were from 3.5 to 30 min. It will be noted that surprisingly little calcium carbonate is converted to the soluble bicarbonate. The raw sludge contained 34 mg/l of dissolved calcium carbonate, due in part to supersaturation. Calcium bicarbonate in carbonated sludge varied from an average of 87 mg/l for a 3.5 min carbonation period to 103 mg/l for a 30 min carbonation period. The latter figure means that only 70 mg/l of insoluble calcium carbonate was dissolved from approximately 36,000 mg/l present—or about 0.2 per cent.

Similar results were obtained by the carbonation of Dayton sludge in laboratory experiments and of Gainesville sludge in pilot plant runs.

The most probable reason for the fact that magnesium can be selectively and fairly completely dissolved from water softening sludges containing much larger amounts of calcium carbonate is to be found in the physical structure of the two insoluble components. Because magnesium hydroxide exists as the gelatinous and bulky coordination complex $Mg(H_2O)_4(OH)_2$, it is probable that the hydrated magnesium hydroxide formed in the softening reaction exists in the form of a polymer. The successive acceptance by the hydroxyl group of protons from the carbonic acid would promote the dissolution of this compound.

Calcium carbonate does not exist as a coordination complex. In water softening sludges, it is a lyophobic crystalloid of extremely fine particle size. Because it has a sodium chloride crystal structure, the energy requirement for dissolution of this compound would be considerably greater than that required for dissolution of the magnesium hydroxide. By the above reasoning, one also may state that although both saturated solutions of magnesium hydroxide and calcium carbonate have approximately the same pH value, the former is a considerably stronger base than the latter.

Conclusions

A study has been made of the carbonation of the sludges obtained in softening the municipal water supplies of Gainesville and Dayton by the lime-soda process. The volume concentrations of carbon dioxide have been limited to those of scrubbed stack gas and of the gas obtained by the recalcination of water softening sludge. The carbon dioxide–magnesium oxide mole ratios employed have been varied from 1:1, or 50 per cent of that required to convert all magnesium hydroxide to the soluble bicarbonate, to 10:1 or five times the theoretical requirement for complete conversion. Studies have been made in the laboratory and in a pilot plant constructed especially for this work.

It has been found that carbon dioxide in concentrations varying from 10 to 33 per cent by volume exhibits a high degree of selectivity in converting insoluble magnesium hydroxide to the soluble bicarbonate in the presence of much greater amounts of finely divided calcium carbonate. The following statements summarize the effect of the several variables which were studied:

1. Conversion of magnesium hydroxide to the soluble bicarbonate is very rapid, about 96 per cent of that

removed from the two sludges studied having been dissolved in the first 15 min.

2. The amount of magnesium hydroxide dissolved is a function of time and the carbon dioxide–magnesium oxide mole ratio. The rate of solution increases rapidly up to a mole ratio of 2:1; beyond that point, as will be noted from the curves of Fig. 2, 3, and 4, the relationship between the rate of solution of magnesium hydroxide and the mole ratio is linear.

3. Percentage removal of magnesium hydroxide was not as great in the pilot plant as in the laboratory experiments. This is believed to be due to the fact that dispersion of the gas in the sludge suspension was much more efficient and bubble size much smaller in the laboratory absorber than in the pilot plant.

4. The percentage of gelatinous, highly hydrated magnesium hydroxide in both raw and carbonate sludges is found to be the main factor determining settleability and final volume after settling. Converting most of the insoluble magnesium hydroxide to the soluble bicarbonate is found to reduce greatly the time of settling and the final volume of the settled sludge.

5. This selective action of carbon dioxide on sludges composed of mixtures of magnesium hydroxide and calcium carbonate has a number of interesting and promising practical applications, both in water treatment and in the treatment and disposal of industrial wastes.

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Discussion

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If sludge from water softening plants is to be recalcined, it is desirable to reduce the magnesium to the lowest practical limit in order to improve the settleability and reduce magnesium buildup in the reburned lime. One method is the carbonation of the sludge prior to dewatering.

The work done several years ago at Findlay, Ohio, and described by the writer showed that when the sludge was diluted to 5 per cent solids and carbonated, settleability was not only improved but, when dewatered in a bowl centrifuge, lower moisture cake and higher solids recovery also resulted.

The author has pointed out the many problems encountered with the process and has described the factors which affect the physical characteristics of the sludge. He shows the difference in results obtained from his laboratory studies as compared to the pilot plant work.

Few data are available for comparison with the results obtained by the authors. Some laboratory work has been done in connection with the Lansing, Mich., and Dayton, Ohio jobs, but these tests were quite limited. It seems apparent that if carbonation is to be undertaken for any project, pilot plant studies should be conducted for the particular sludge used or, if that is not possible, a sludge as nearly comparable as possible.

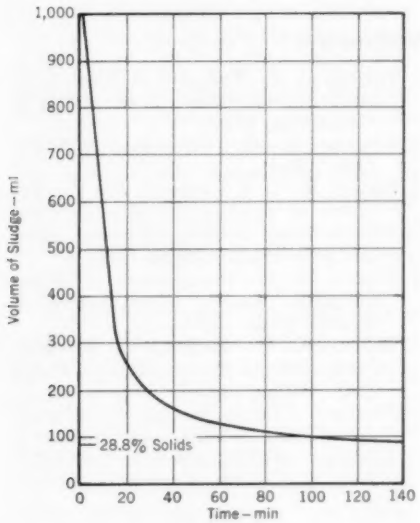


Fig. 6. Settleability Curve for Test at Dayton

Sludge contained 2.54 per cent solids carbonated to pH 7.32.

Dayton Tests

The Dayton tests were conducted on a sample containing 24 per cent solids with a magnesium content of 2.1 per cent or 5.05 per cent as magnesium hydroxide. Carbonation tests were run using a ratio of 25 per cent carbon dioxide to 75 per cent air. This ratio was chosen because it was assumed to be the ratio of carbon dioxide to be expected in the stack gas from the proposed recalciner.

The first test was run on a portion of the original sample which was diluted with supernatant from that sample to 2.65 per cent solids by weight. The diluted sample then showed 677.1 mg/l magnesium or 6.14 per cent magnesium hydroxide on a dry-solids basis. The initial pH was 10.6 and it was gassed for 9.75 min with 25 per cent carbon dioxide, when 1.4 liters of carbon dioxide per liter of slurry had been added. Computed on the basis of a mole ratio of carbon dioxide to magnesium oxide, it is equivalent to 2.26:1.

The pH after gassing was 9.1 and the magnesium in the liquor was 239 mg/l. The magnesium removal, there-

TABLE 3

Effect on pH of Carbon Dioxide, With and Without Mixing

Without Mixing

Mole Ratio (CO_2/MgO)	pH (Using Pure CO_2)
—	11.3
0.295:1	10.0
0.810:1	9.5
1.070:1	9.0

With Mixing

Mole Ratio (CO_2:MgO)	pH (Using Pure CO_2)	pH (Using 10% CO_2)
0.141:1	10.5	10.8
0.435:1	9.7	10.0
0.590:1	9.4	9.8
0.790:1	9.3	9.5
0.880:1	9.1	9.3
1.020:1	9.0	9.2
1.180:1	—	9.1
1.320:1	—	9.0

fore, was approximately 35.3 per cent. Sufficient carbon dioxide was added to convert the magnesium to bicarbonate, but it seems quite evident from the results that the time interval was too short to complete the reaction.

The gassing equipment consisted of an 8-liter battery jar into which were fitted two coarse 30-mm gas diffusers and an agitator. The carbon dioxide and air were metered by manometers and mixed prior to entering the gas diffusers.

The second test was conducted in a manner similar to the first. The total solids were 2.45 per cent, and the magnesium analysis showed 517 mg/l, or 5.12 per cent magnesium hydroxide on a dry-solids basis. The initial pH was 10.5.

The net gassing time was 42 min, but this was done intermittently over a period of 115 min. The volume of carbon dioxide used was 2.4 liters per liter of slurry or a carbon dioxide to magnesium oxide mole ratio of 5.05:1. The pH dropped as low as 7.32, but after the last rest period was 7.4. After a 3-day rest period, however, the pH was 8.2 and the magnesium in the filtrate dropped from 420 to 380 mg/l. On the basis of 420 mg/l, the magnesium removal was approximately 81 per cent. The filtrate contained some calcium in the ratio of 1:4.75 magnesium expressed as bicarbonates.

Fig. 6 shows settling rates for the second test. It will be noted that there was straight-line settling until the sludge had a solids content of about 8.5 per cent. After 160 min settling, the solids in the sludge constituted 28.8 per cent.

Lansing Tests

The Lansing carbonation was carried only to the point where the magnesium was converted to normal carbonate or a pH of approximately 9.0. The relationship of pH to carbon dioxide used is shown in Table 3. The samples contained 12 per cent solids which, on the basis of dry weight, were approximately 87 per cent calcium carbonate and 9.4 per cent magnesium hydroxide.

The first test was conducted with pure carbon dioxide added through a canvas diffuser and with no stirring other than that created by the gas. In the second test, the gas was admitted through ⅛-in. diameter pipes and the slurry continually stirred with a mechanical mixer.

TABLE 4

Effects of Prolongation of Carbonation

pH	Feed Rate *gpm*	$CaCO_3$ Recovered—%	Mg (as $Mg(OH)_2$) in Cake—%
11.3	10.6	84.3	5.0
9.5	10.6	82.7	4.4
9.0	10.6	82.1	2.6

The settleability was improved, but was not spectacular and the results are not included in this discussion. There were indications, however, that when the carbonation was prolonged to the point where magnesium was converted from hydroxide to normal carbonate, a greater percentage would be rejected in a solids bowl centrifuge. The data gathered, shown in Table 4, indicated this to be true.

Unfortunately, these tests were not checked and the results can be considered only a trend. More work should be done on this phase.

The author has shown better results in his laboratory studies than were obtained in the pilot plant at Gainsville. He attributes this to the use of finer

gas bubbles in the laboratory experiments. No mention is made of the use of stirring in the pilot plant studies and it is assumed that none was used—except that of the stirring action produced by the gas bubbles. Work by writer's company has indicated that stirring during carbonation is desirable, being increasingly important as the percentage of solids in the slurry increases.

Conclusions

1. The work of the authors has added a great deal of useful information on the benefits of carbonation of sludge.

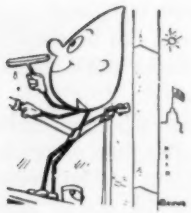
2. Converting the magnesium to the normal carbonate does not appear to improve the settleability a great deal.

3. There are indications that converting magnesium to the normal carbonate lowers the magnesium remaining in the cake from a solids-bowl centrifuge.

4. Reducing magnesium to bicarbonate gives good removal of magnesium and greatly improves the settleability of the sludge.

5. Carbonation offers a simple and economical means of keeping the magnesium content within practical limits, making it possible to produce a high quality recalcined lime from water softening sludge.

6. Because of the variable nature of water softening sludge, pilot plant as well as laboratory studies should be conducted before designing carbonation and thickening equipment for magnesium removal and thickening of sludge.



Effects of Synthetic Detergents on Water Supplies

Task Group Report

A report of Task Group 2661 P—Effects of Synthetic Detergents on Water Supplies, presented on May 15, 1957, at the Annual Conference, Atlantic City, N.J., by Paul D. Haney, Cons. Engr., Black & Veatch, Kansas City, Mo. Other members of the task group were R. L. Culp, J. D. Enright, W. D. Hatfield, H. P. Kramer, H. E. Lordley, and J. C. Vaughn.

FOSTER D. Snell (*1*) has stated that although the synthetic detergent (syndet) industry actually started in 1932, it has had its major growth since 1948. Since 1948 the industry has had to convert more than half its production from soap to syndets. Snell compares the magnitude and importance of this change to that from oil base to latex base paints, "or in another area, from radio to television."

During 1948 synthetic detergents accounted for about 16 per cent of soap industry sales. During 1956 they represented nearly 70 per cent of the market. Syndet production during 1955 exceeded two billion pounds.

All synthetic detergents depend upon some surface-active agent that does not precipitate in hard water. The principal surface active agent used for current syndet production (*1*) is "the sodium salt of the sulfonation product of dodecylbenzene." This may also be termed alkyl benzene sulfonate or simply ABS. The concentration of surface active agent in synthetic detergents ranges from about 20–40 per cent. In addition to the surface-active material syndets contain 30–50 per cent of a molecularly dehydrated phosphate principally sodium tripolyphosphate. They may also contain up to 10 per cent sodium silicate, as anticorrosion ingredient. Sodium sulfate is also a constituent, the amount depending upon the process by which the surface-active agent is made. Many syndets contain a small percentage of condensed amines for foam stabilization as well as a small percentage of carboxymethylcellulose, which is useful in preventing redeposition of soil on fabrics. Minor ingredients include optical bleaches and dyes.

From the standpoints of water supply and waste water disposal Snell's (*1*) comparison between soaps and syndets is considered significant.

> Soaps as a class are composed roughly of 60–80 per cent organic matter. In contrast to this, syndets are roughly 25 per cent organic. So this revolution, from the use of soap exclusively to the use of two-thirds syndets and only one-third soap, has transferred a large piece of business—from the soap kettle, farm, and slaughter house to the chemical manufacturing plant. Instead of inedible fats, a considerable part of the basic raw material is a synthetic alkylate derived from the petroleum industry, sulfuric acid, and phosphorous derivatives.

British Findings

During 1956 the report of a British study (*2*) was released. This report cites work carried out in the laboratories of the London Metropolitan Water Board relative to the persistence of surface-active materials through normal water works processes. Conclusions were as follows:

1. Storage of river water in a reservoir for 3 weeks reduced the concentration of surface-active material by 20–50 per cent depending on temperature. As much as 20–45 per cent of the active material originally added might persist for as long as 6 months. Any reasonable period of storage would not produce a reduction of more than 50 per cent.

2. Slow sand filtration produced a reduction in surface-active agent material of 13–50 per cent, depending on temperature.

3. Treatment of a hard river water with aluminum sulfate and activated silica and then by rapid sand filtration had only slight effect. The reduction was of the order of 10 per cent.

4. Experiments with activated carbon showed that this material was effective in removing surface-active material from water. The dosage required, however, was extremely high—for example, 75 per cent removal required a carbon dosage of 100 ppm.

5. The chlorination process is not adversely affected by the presence of surface-active material in concentrations of 6.5 ppm. Normal chlorine dosage has no effect upon the surfactant concentration.

Additional experimental work showed that a mixture of proprietary synthetic detergents at a concentration of 0.8 ppm of surface-active material could cause persistent foam. No foam has been noted, however, in any British public water supplies as delivered to consumers. Some foaming has been observed on rivers at water works intakes. The British committee further observed that although the fundamental aims of detergency are directly opposed to those of water treatment, the present concentration of detergents in British waters are apparently not of an order sufficient to cause conflict. So far as observed there has been no evidence that the presence of synthetic detergent residues has affected the purification processes in any British water works.

The British report also states that in areas where the public water supply is derived from rivers to which sewage effluents are discharged upstream, the drinking water must contain traces of synthetic detergent materials. At present there is no evidence of short-term ill effects; the possible effects of repeated ingestion over a long period is another matter, however, and it is clearly desirable that the question be kept under review.

American Reports

One of the major concerns has been the reported resistance of alkyl benzene sulfonate (ABS) to biological degradation. Sawyer and others at the Massachusetts Institute of Technology have reported on the biological degradation of a variety of surface-active materials. Sawyer, in an article published in 1956 (*3*), concluded that the anionic (ABS is an anionic substance) and nonionic materials used in commerce today appear to be subject to biological attack but vary greatly in their susceptibility. This variation is believed to be largely related to differences in chemical structure. For example, in the polypropylene derivatives of benzene a branched alkyl group apparently blocks

degradation almost completely. Of the nonionics some are readily attacked by bacteria while others, particularly the high polymers, are quite inert. Sawyer attributed this difference in behavior to difference in molecular size.

An additional significant contribution is the recent article by Sawyer and Ryckman (*4*). These investigators concluded that all anionic surface-active agents except the alkyl benzene sulfonates derived from propylene are subject to biological degradation. They further stated that water supply problems related to anionic surface-active agents are most likely to be caused by polypropylene benzene sulfonates, as a result of their resistance to biological degradation and to their popularity among producers of synthetic detergents.

Considerable research, sponsored by the Association of American Soap and Glycerine Producers, is now under way in the United States. Projects relating to the biological degradation of ABS are in progress at the Massachusetts Institute of Technology and the University of California. The latter project is employing radioactive, S^{35}-tagged, ABS in connection with studies of its removal by the activated-sludge sewage treatment process.

Frothing at sewage treatment works has become a fairly serious problem. Sawyer and Bogan (*5*) have investigated frothing and have indicated that the presence of a branched-structure alkyl group in any alkyl-aryl detergent appears to be conducive to foaming, other things being equal. This is considered significant, inasmuch as it is this type of surfactant that is the most resistant to degradation.

Additional research on the subject of frothing, sponsored by the Association of American Soap and Glycerine Producers, is now under way at the University of Wisconsin. The objective of this work is an investigation of the fundamental factors causing frothing and the development of means of reducing or eliminating it.

Synthetic detergents contain a high proportion of phosphate compounds and it has been demonstrated by Smith, et al. (*6*) and Howells and Sawyer (*7*) that these substances can interfere with alum coagulation, particularly in soft waters. Further information on this as well as the persistence of complex phosphates in natural waters is the subject of a research project at the University of Illinois. This project has the following major objectives:

1. To establish the levels and kinds of phosphates normally present in typical surface waters
2. To determine the persistence of complex phosphates during sewage treatment, water treatment, and in surface waters
3. To determine the effects of complex phosphates on water treatment processes.

A great deal of first-class research talent has been brought to bear on the synthetic detergent problem as it relates to the broad field of public water supply. Particularly gratifying has been the excellent cooperation received from industry through the Association of American Soap and Glycerine Producers.

Publication of research results is awaited with interest. This will add to a rapidly expanding backlog of information that will enable those concerned to approach the whole question of synthetic detergents on a rational basis. Eventually, speculation can be replaced by factual data. This task group will attempt to keep in touch with future developments and to report them to the Association.

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R615	MURDOCH	Too Cheap Water	Aug 56	6	25¢
R616	MCCAULEY	Engineering Reports	Sep 56	5	20¢
R617	BARRETT	Galvanic Corrosion in Meters	Oct. 56	8	25¢
R618	CARNS	Service and Meter Sizing	Oct 56	7	25¢
R619	BECKER, RUGGLES	Pipe Laying	Nov 56	10	25¢
R620	WOLMAN	Long-Range Planning	Dec 56	6	20¢
R621	NORTH	Construction Cost Indexes	Dec 56	6	20¢
R622	NIEMEYER	Distribution System Maintenance	Dec 56	10	25¢
R623	NIEMEYER	Continuous Leak Survey	Dec. 56	6	20¢
R701	TASK GROUP REPORT	1956 Fluoridation Census	Jan 57	7	20¢
R702	TASK GROUP REPORT	Fluoride Color Comparator Kits	Apr 57	10	25¢
R703	PANEL DISCUSSION	Plastic Pipe	Apr 57	11	25¢
R704	STAFF REPORT	1955 Operating Data Survey	May 57	144	75¢
R705	WOLMAN	Radioactive-Waste Disposal	May 57	7	20¢
R706	COMMITTEE REPORT	National Water Resources Policy	Jul 57	9	25¢
R707	BARRON	Stray-Current Corrosion	Jul 57	6	20¢

Factors Affecting Long-Distance Transmission of Water

Louis R. Howson

A paper presented on Jun. 17, 1957, at the Canadian Section Meeting, Winnipeg, Man., by Louis R. Howson, Partner, Alvord, Burdick & Howson, Chicago, Ill.

ALTHOUGH long distance transmission of water for public use is not new, probably few realize that one of every eight people having access to public water supplies on the North American continent takes water from a system which transports it 75 miles or more.

There are many reasons why this situation has developed. Necessity required Los Angeles, which first utilized close-in sources, to develop the 250-mile Owens Valley Aqueduct supply and later the supply from the Colorado River 400 miles distant. In other cities, such as New York, the effort to date has been to develop upland supplies which are used without filtration. In the Saginaw-Midland area, cities having modern purification plants were unable to cope with the increasing industrial waste in the river supplies and, therefore, constructed an 83-mile transmission main to bring water from an intake into Lake Huron at a point remote from contamination. Tulsa, Okla., abandoned its river supply after it had been contaminated by brine from oil wells, and developed the Spavinaw impounded supply. In the Seattle, Portland, East Bay, and San Francisco areas, growth in requirements, elevation, source of supply, and quality were all important considerations. Winnipeg abandoned its local sources more than 40 years ago and brought water through a 97-mile gravity transmission line from the Lake of the Woods, at the International boundary. Denver, having exhausted the water resources available on the east slope of the Rocky Mountains to the maximum extent without taking water from irrigation users, has developed and is now enlarging its transmountain, western-slope, Moffat Tunnel source and is constructing a 23-mile tunnel through the Continental Divide to divert west-slope water from Blue River to Denver.

The magnitude of long-distance public water supply transmission can be visualized by realizing that approximately 12,000,000 tons of water per day are handled in these long-distance transmission operations. That is more tonnage than is handled by all of the common carriers, including railroads, barge lines, and trucks.

In some locations, particularly those adjacent to mountainous areas, where differences in elevation are adequate for gravity flow, the long-distance transmission of water may be accomplished by open channels or pipelines without pumping. Water flowing through pipelines, however, is subject to friction and loss of head, and most long transmission lines in the generally

level or slightly rolling country of the midcontinent require pumping stations as well as pipelines.

Construction Materials

Aside from tunnel construction, as on the New York aqueducts and the Denver transmountain diversion, long-distance transmission through conduits is usually accomplished using concrete or steel materials.

Steel pipe has been used on this continent for more than 100 years. It was the predominant material used for the larger sizes and high heads prior to the development of reinforced concrete pressure pipe, with which it is now in general competition.

Steel pipe has great strength, permitting the use of relatively thin shell construction, the minimum thickness of which is frequently governed by conditions other than internal bursting pressure. Steel is also a ductile material, so that it can yield or deflect under load without failure. When leakage occurs it is usually the result of pitting, and rarely results in failure of the pipe. This fact of maintained structural strength even after leakage has occurred has led to the development of techniques of cleaning the interior of old steel conduits and lining them in place with centrifugally placed cement mortar. This lining makes the lines watertight, and at the same time usually results in a Hazen-Williams coefficient of roughness (index of carrying capacity) higher than that of the original steel pipe.

The susceptibility of steel to corrosion has led to the development of protective lining and coating materials. The inside coatings most widely used are of coal-tar enamel and cement mortar. The latter can be applied either at the pipe mill or after the entire line is in position and has taken its permanent shape. It has been reported that in the Los Angeles area cement linings can be applied in place at a cost no greater than at the mill. Where that can be done, there is an advantage from the carrying capacity standpoint.

The exterior of steel pipe should also be protected. In most soils it is believed the pipe should be wrapped with asbestos fiber in addition to the coal-tar enamel coating.

The AWWA has developed standards for steel pipe and linings (1–3), and a manual of practice for its installation is now nearing completion.

Reinforced concrete pressure pipe was first used approximately 40 years ago, although both monolithic and precast concrete pipe had been largely used for sewers and gravity lines prior to that time. During the years the design of this pipe has passed through many changes both in the joint design and the design of the pipe shell itself. In general, it is considered sound practice not to use reinforced concrete pipe for pressure service where the head exceeds 100 ft of water without having as a part of the construction an interior cylinder of steel.

One of the early reinforced concrete pressure pipelines in this country was the 84-in. and 108-in. pipe used as tunnel liner in Baltimore in 1914. This pipe was equipped with a copper stop type of joint which, while difficult to install, was generally effective. Part of the Winnipeg line, consisting of 58,000 ft of 66-in. pipe, was laid utilizing the copper joint in 1917. This is a part of the long line from Winnipeg to the Lake of the Woods, to which earlier reference has been made.

The copper joint was followed by a machined cast-iron ring using a lead

gasket for sealing. That type of joint was first used at Cumberland, Md., which also used the first reinforced concrete pipeline in which a watertight steel cylinder was incorporated in the construction.

There were other types of reinforced concrete pipe and joints, including such lines as the 84-in. low-pressure well line at Dayton, Ohio, where a poured sulfur compound joint was used.

It was early found and frequently stated that "concrete pipe was as tight as its joints," so that continued attention was given toward the development of a tight, more easily installed, less costly type of joint construction. The next development was the steel joint ring with a fibre-filled lead gasket calked from the inside of the pipe. This was an excellent joint, and is still sometimes used, although for the last 10–15 years it has largely been superseded by the roll-on type of rubber gasket, compressed between grooved steel rings welded to the steel cylinder cast in the concrete. This type of joint, first introduced in 1934, widened the field of concrete pressure pipe to all sizes from 20 in. and larger. Prior to that time the lower limit of size was 36 in., due to difficulties of calking the lead gaskets from the inside of the pipe in smaller sizes. Concrete pressure pipe from 16 to 150 in. diameter is now in service.

Paralleling the advances in joint design, concrete pressure pipe has progressed through successive stages from: [1] cast concrete with bar cage reinforcement, both noncylinder and having steel cylinder, to [2] prestressed pipe, first used on the Washington Suburban Sanitary District 30-in. line in 1942, and finally [3] the embedded cylinder type of prestressed pipe, developed in 1952 and particularly adapted to use in the larger sizes and under moderate to high heads.

Cast-iron pipe has been used for some transmission lines in the past, such as the 48-in. Wichita line. It is not competitive in cost under present conditions, and its characteristic of fracture, which is sudden and complete, is less desirable for large pipe than that of steel and reinforced concrete, both of which depend upon the more ductile steel for protection against sudden rupture.

The selection of the pipe size and material is influenced by several factors, including:

1. Cost of the installation
2. Estimated life of the materials of construction
3. Coefficient of roughness, which affects friction head and power used for pumping
4. Cost of power used for pumping.

These factors are largely economic and are capable of being computed with reasonable accuracy.

Installation Cost

Under cost conditions prevailing in 1957, with the *Engineering News-Record* Construction Cost Index at about 710 (1913 = 100), it is usually practicable to construct transmission lines of 20 miles or more in length within a price range of 60–75 cents per foot per inch of diameter in areas where rock excavation is not a serious factor and machine trenching and backfilling are practicable. The cost rarely exceeds $1 per foot per inch of diameter in built-up areas, exclusive of paving costs.

Cross-country costs averaging $125,000 per mile of 36 in. line and $200,000 per mile for 60-in. line are fairly representative for steel and reinforced concrete lines in 1957.

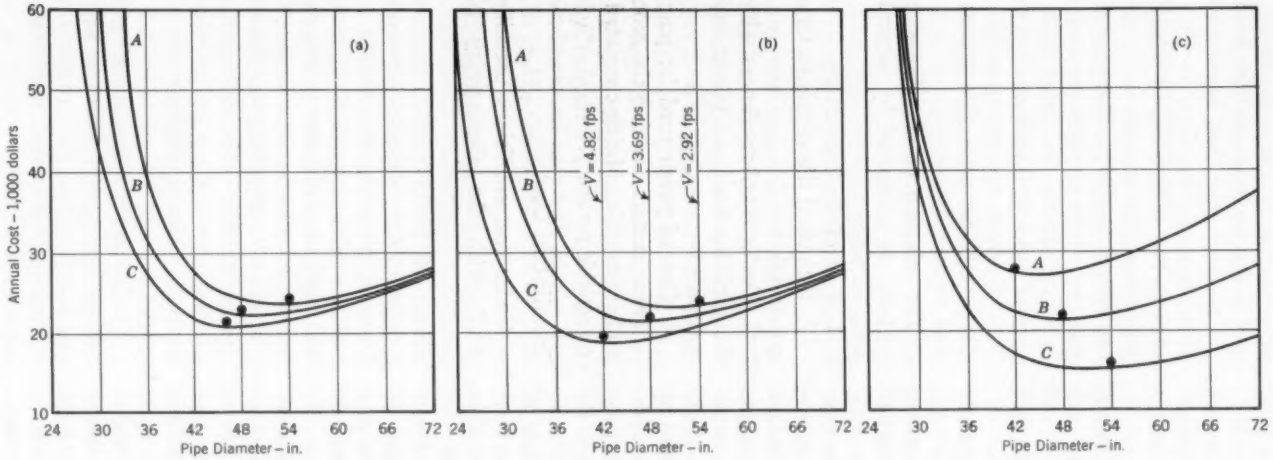

Fig. 1. Economical Pipe Sizes, Based on Hazen-Williams Coefficients, Power Costs, and Pipe Costs

Figures in all three graphs are based on the following conditions: length of main, 10,000 ft; quantity (Q), 30 mgd; fixed charges of 5 per cent; no static head; and pump unit efficiency of 74.6 per cent. Dots indicate sizes of pipe meeting the requirements most economically.

a. Hazen-Williams Value: *With pipe costs of 75 cents per inch of diameter and power costs of 1 cent per kilowatt-hour, curves represent the following* C *values:* A, *100;* B, *120; and* C, *140.*

b. Power Costs: *With pipe costs of 75 cents per inch diameter and a* C *value of 140, curves represent the following power costs per kilowatt-hour:* A, *1½ cents;* B, *1 cent; and* C, *½ cent.*

c. Pipe Costs: *With power costs of 1 cent per kilowatt-hour and a* C *value of 140, curves represent the following pipe costs per inch of diameter:* A, *$1;* B, *75 cents; and* C, *50 cents.*

Life of Materials

The life expectancy of cast-iron pipe is known to be long. The AWWA committee report on survival and retirement of water works facilities (*4*), which summarized the records of 61,000,000 ft of cast-iron pipe laid in the period from 1817 to 1945, found that over 96 per cent of all such pipe 6-in. and larger laid in that period was still in use. Valuation engineers commonly give cast-iron pipe a life expectancy of 100–200 years.

Steel pipe is more subject to corrosion, a factor which has led to protective coatings both inside and outside. The background of experience with coated steel pipe is not as long as that with cast-iron pipe, but such experience as is available would indicate that coal-tar enamel–coated, asbestos fiber–wrapped pipe with spun coal-tar enamel lining on the interior should have a life expectancy of 50–75 years and with cement-mortar lining about 100 years.

Reinforced concrete pressure pipe is also a newer type of construction, but one whose material (cement or concrete) has been extensively used to carry water or to line pipes of other material carrying water for 75 years or more. Fred C. Scobey, of Berkeley, Calif., who has probably inspected and tested more pipe for carrying capacity than any other engineer, recently stated, after again examining some concrete pipe after 70 years of service: "The conviction has grown that there is no need to restrict the life of premium concrete pipe to 100 years in calculations leading to annual costs." One hundred years, however, is the life expectancy most generally used for concrete pressure pipe.

In line with the foregoing discussion the annual depreciation allowances on a straight line basis would be ½–1 per cent per year for cast-iron pipe, 1–2 per cent per year for steel (depending upon protective coatings), and 1 per cent per year for reinforced concrete.

Coefficient of Roughness

The coefficient of roughness of the pipe interior measures its resistance to flow. For new, well laid, cast-iron lines a Hazen-Williams coefficient C of 125 is usually obtained. With Great Lakes water before treatment, this coefficient has usually dropped about 2 points per decade, or to about 115 after 50 years in service. Following treatment of the water, some Great Lakes cities have experienced an acceleration in this rate of loss of carrying capacity. This is now the subject of research by the AWWA, under the leadership of T. E. Larson of the Illinois State Water Survey (*5–8*).

Modern spun coal–tar enamel linings for steel pipe give promise of sustained carrying capacity for the pipe to which they are applied. Tests of such lines usually show a Hazen-Williams coefficient of 135–140 for lines 36 in. and larger when new. There are few data regarding tests of such lines after extended service.

Scobey has reported on 15 tests of new cement-lined steel pipe having an average Hazen-Williams coefficient of 146. Two of these lines were tested 17 years later and found to have the same coefficient as when new.

There have been many recorded flow tests on reinforced concrete pipe. Scobey reports 38 such tests having an average Hazen-Williams coefficient of 147. Experience has generally been that original coefficients are well main-

tained and sometimes improved in service. Denver Conduit 10 increased its *C* from 141 to 150 after 18 years in use, due to the slime which during that period of service had displaced the original wash coat on the pipe interior.

Present day reinforced concrete pressure pipe in sizes 36-in. and larger made by experienced pipe manufacturers can be safely given a Hazen-Williams coefficient of 145–150.

Figure 1a illustrates how the coefficient *C* affects the selection of the economical pipe size. Under the assumed conditions of pipe costing 75 cents per foot per inch diameter and power costing 1 cent per kilowatt-hour, with a coefficient of 140, a 46-in. diameter pipe will meet the requirements most economically, while with a *C* value of 100, a 54-in. line would be the most economical. The cost of the 54-in. exceeds that of the 46-in. pipe by about 17 per cent. Expressed in another way, the annual cost of a 48-in. line with a 100 *C* value would be 14 per cent higher than if the *C* were 140.

From the example it is possible to evaluate the effect of the Hazen-Williams coefficient in the range here discussed as approximately $\frac{1}{2}$–$\frac{1}{3}$ per cent change in cost for each point variation in the coefficient value.

There is usually no evaluated difference for carrying capacity as between cement-lined steel and reinforced concrete pressure pipe.

Power Costs

Next to fixed charges, the largest item of annual cost on a long transmission line project is usually that of purchased power. Obviously, the fixed charges increase, but power costs decrease as the diameter of the pipeline is increased. The most economical size of line is that for which the sum of fixed charges and power cost is the lowest.

Figure 1b illustrates the effect of the unit cost of power per kilowatt hour on the selection of the economical size. Under the conditions assumed, the most economical size of line with $\frac{1}{2}$ cent per kilowatt hour power would be 42 in. With power costing 1 cent per kilowatt hour, the most economical size would be 48 in., and with power at $1\frac{1}{2}$ cents per kilowatt-hour, it would be 54 in.

Since a 200 per cent increase in the cost of power will offset a 30 per cent increase in cost (and fixed charges thereon), these figures indicate a general relationship that 7 per cent variation in unit power cost is required to balance each 1 per cent increase in pipe size and cost.

It is apparent that, other elements of cost remaining constant, any variation in the cost of the line installed will affect the selection of economical size. Figure 1c has been prepared to illustrate that relationship over a range of cost from 50 cents per foot per inch diameter for a very cheap installation to $1 per foot per inch in a more congested or rock trench area. For the cheaper installation a 54-in. line is indicated as the economical size, as compared to but 42 in. for the difficult and costly line.

The annual cost of the project would be increased about 75 per cent if the cost of pipe installed increased 100 per cent for pipe sizes within the economical size range.

Variation in Flow Rates

Friction head and power costs vary approximately as the square of the flow. The preceding discussion has related primarily to selection of pipe sizes over a line length such as can be served

by one pumping station. With long pipelines, multiple stations are usually necessary. Under such conditions the pipe and the pumping station are usually designed for a 300–400-ft head. With reinforced concrete pipe the design can be increased above 300 ft at an increase in cost of approximately 10 per cent for 100-ft head change.

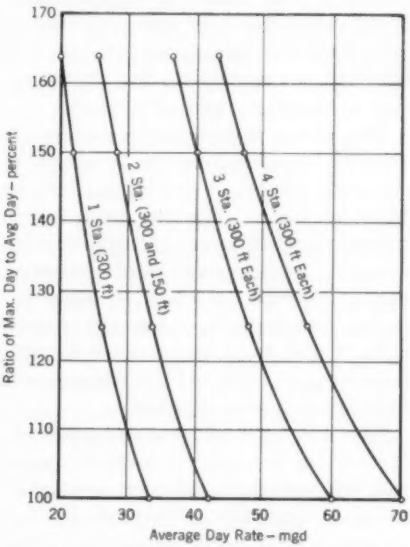

Fig. 2. Effect of Pumping Rate Variations

Curves show the effect of variations upon the number of stations required on the Saginaw-Midland project. Figures are based on a 48-in. main line, 36-in. branches, and a C value of 140.

In a pipeline normally operating at 300-ft friction head, doubling the flow would result in about a 1,200-ft friction head. This would usually be met by providing four stations, each lifting the water 300 ft. Transmission lines are costly to construct and duplicate, and are of very long life expectancy. They are therefore frequently designed for step enlargement, by adding intermediate pumping stations along the line as the demand for water increases. It is frequent practice in the design of long pipelines to design the line for initial operation with a single pumping station. As the quantity increases a second station can be built near the center of the line and the capacity stepped up about 40 per cent. As this capacity is reached, two additional stations can be built near the quarter points of the line and its capacity raised to approximately double the initial capacity. This type of design is shown in a study made for the Saginaw-Midland line (*9*), where the ratio of maximum to average day was about 1.6:1.

Figure 2 shows the effect of variations in pumping rates upon the number of pumping stations required on the Saginaw-Midland project. From this diagram it is observed that under the conditions of this study covering level terrain, a single pumping station could deliver a 33 mgd rate, but if the peak day pumpage were 160 per cent of the average day (a common relationship), the capacity of the station would be only 20 mgd. This station would operate against a 300-ft head.

With four stations, each operating at a 300-ft head, the peak would be 71 mgd, but if the maximum day were 160 per cent of the average day, the stations' average day's capacity without carryover storage would be only 43 mgd. In both cases it was assumed that storage necessary to iron out hourly variations in water requirements was provided at the terminus of the line.

Terminal Storage

Although it is rarely economically worthwhile in the design of distribution storage to provide more than enough capacity to equalize hourly variations (usually 10–20 per cent of

the 24-hr use), a much more liberal provision is desirable for long transmission lines. Where terminal storage is readily available at reasonable cost it should be provided, even in some cases to the extent necessary to permit the pipeline to operate at a uniform rate which is the average for the year. Denver and Fort Worth are excellent examples of cities with adequate terminal storage. In most localities storage in this amount is not practicable.

Terminal storage is largely a question of economics when conditions are such that it is physically possible to construct the storage required. The amount of storage will depend upon the relationship of the maximum rates of consumption to the pipeline capacity, but the amount which can be justified economically will depend upon the reduction in size of the pipe which can be secured by a given amount of storage considered with respect to the length and cost of the pipeline involved. The saving in pipeline cost must be enough to pay for the storage if terminal storage is to be adopted as a means of reducing the size of the pipe in the initial construction. It can be sometimes added later when increased demands or peak rates would otherwise require additional transmission or pumping capacity.

To illustrate the problem, analyses have been made of the pumping statistics of three midwestern cities. Two of these cities supply a large amount of water to industries; the third city is largely residential and commercial. These studies showed that storage of from 15 to 30 days average use would be required to enable a transmission line to operate at a uniform rate throughout the year, the smaller amount of storage being required where the industrial load lowered the ratio of maximum to average-day's use.

Similarly, it would be possible by providing terminal storage capacity equal to from 3 to 5 days' use to operate the transmission line facilities at a rate equal to the average days' use of the maximum month, which rate would be from 15 per cent to 35 per cent above the annual average. Thus, about one-fifth of the storage required for a uniform average annual rate will effect approximately one-half the reduction in the peak rates of pumping.

The above figures are generally indicative of conditions in localities of adequate rainfall—namely, east of the Missouri River. Further west, where irrigation peaks are large and of long duration, more storage would be necessary. Terminal storage of large capacity is usually economically practicable where it can be provided in open reservoirs constructed in balanced excavation and embankment.

The cost of reinforced concrete reservoirs for terminal storage is rarely justified, although sufficient storage to provide flexibility of operations and adjustment for power outage and similar operating problems is essential.

Under the conditions studied in one of the midwestern cities, storage equivalent to 20 days' use would enable the pipeline and pumping stations to deliver 27 mgd more water than could be delivered without the storage. The estimated cost of this pipeline and pumping stations was approximately $20,000,000, the equivalent of $280,000 per mgd of capacity. The additional 27 mgd capacity made available by terminal storage would therefore be worth about $7,500,000. Providing the required storage in a reinforced concrete reservoir would cost over $7,000,000. It is being made available in earth

excavation and embankment at but a fraction of this amount.

Additional Considerations

Surge: Adequate protection must be provided against surge in long transmission lines, particularly those with electric pumping equipment. It is the usual practice to install an automatic solenoid-controlled cone or ball valve on the discharge line of each pump, with its operation tied in with the pump motor controls and its time of opening and closing made to conform to the surge characteristics of the pipeline. These valves close automatically with power outages.

The pipeline must be protected against surges resulting from power outages as well as pump operations. The most common type of installation for this service consists of multiple units of spring-loaded,quick-opening valves that give stepped relief as the surge grows and keeps the maximum within the safe limits of the pipeline design.

Pumping stations: Although the spacing and head per station are individual problems, the general pattern of long lines is to have pumping stations located at 15–25-mile intervals and operating against 300–400 ft heads. The cost of stations and equipment averages from $100 to $125 per horsepower of installed capacity. Stations operating in series are usually each provided with a suction storage or surge reservoir.

Dual supply: Sometimes a city has a supply which has been normally adequate but which cannot be expanded for the growing needs. It then may consider an incremental supply, possibly from a very adequate but remote source, requiring a large transmission line and also a large expenditure. Such a project usually cannot be financed or justified on an incremental basis. If it is to be used only for peak requirements, the costs are usually so great as to defeat the project. A good load factor reduces unit costs. Facilities such as transmission lines have long lives and are accordingly built initially to meet the anticipated future needs. Accordingly, their annual cost per million gallons is usually highest when first built, progressively decreasing as the capacity is more fully utilized.

Conclusions

In determining a water development policy, it is prudent to take a long look into the future and weigh all elements of cost and savings and all advantages and disadvantages of each alternative practicable source before reaching a decision. Quality and adequacy considerations may outweigh those of construction cost. Water cost is low on this continent as compared to any other utility service. A city cannot afford a poor or inadequate water supply. This fact is illustrated by Allen Hazen's reply to the question of how much a city can spend for a water supply, namely, "Whatever it has to"; and William Mulholland's statement when advising Los Angeles to build the Owens Aqueduct: "One thing is sure; if Los Angeles does not get additional water, it will never need it."

Many "cheap" supplies are costly when all factors are considered. This is particularly true where the present supply is materially harder or more difficult to treat than another supply with which it is compared. Savings from reduced expenditures for soap, detergents, and household softeners, lower insurance rates made available by an abundant water supply, and community growth resulting from industry

attracted by an abundance of good water are all factors to be considered.

Each water supply problem has its own variables and must be separately studied. A general discussion such as this can but refer to some of the factors and attempt to show the relative importance of some of them. There is a tendency to develop more adequately and to provide water of better quality, and more cities are going further in order to secure these objectives. Long-distance transmission of water is receiving more consideration now than ever before.

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Wisconsin's Policy on Municipal Utility Taxation

Arthur P. Kuranz

A paper presented on May 16, 1957, at the Annual Conference, Atlantic City, N.J., by Arthur P. Kuranz, Mgr., Water Utility, Waukesha, Wis.

AS far back as 1918, the Public Service Commission of Wisconsin recognized a tax equivalent on municipally owned public utilities in determining rates for the municipal utility. During the period from 1918 through 1937, the commission did accept arbitrary tax payments, which were fixed by the local assessor on a basis about the same as the assessor had used to fix assessments on other manufacturing establishments. These amounts varied considerably, so at different times studies were made to establish a more equitable basis.

In 1937, Chapter 66 of the statutes of the state of Wisconsin was modified to read as follows: "The income of a public utility owned by a municipality shall first be used to meet operations, maintenance, depreciation, interest, sinking fund requirements, local and school tax equivalent, additions and improvements, and other necessary disbursements or indebtedness."

The Public Service Commission, in establishing a uniform system of accounting for these utilities, made provisions for a charge which the local utility would be required to pay to the local municipality, the same as if the utility were privately owned. Many of the municipalities had the local assessor examine the books of record each year, which records were made by the local utility on demand of the state government through the commission. This examination was followed by the development of an assessment by the local assessor on the same basis as that which was used on similar property in the city, which usually found the utility property classed in the manufacturing group.

The assessment so developed became the basis on which the municipal government and school tax rates were applied. The dollar value was paid to the municipality in actual cash and so recorded on the utility books and reported yearly to the commission.

This seemed proper for a time, but the commission found out that there was no uniformity in the actual tax paid on property of similar value. Many municipalities were using the local utilities as collectors of money through rates which were not comparable to other utilities furnishing the same commodities or service. This was in violation of the operation of utilities, and eyebrows were often raised by many. Since the commission is also an arm of the state government, not too much could be done about it. Home rule government is quite a fixed idea in the state of Wisconsin, so every move to make utility rates effective had to be approached very carefully. Furthermore, very few people in Wis-

consin realize or appreciate the fact that local utilities pay very high city taxes.

Commission Action

The Public Service Commission, however, is charged with the primary duty of seeing that the user of services of *all* utilities, whether privately or municipally owned, obtains the lowest rate commensurate with proper service. It prides itself on administering its affairs and duties in this manner. Therefore, in 1955, it decided to give thought to the problem of establishing some sort of equitable manner for paying taxes.

After some preliminary discussion, hearings were held, and the matter of taxes got a very good airing.

The order which resulted was that municipally owned public utilities were to be treated the same as if they were privately owned, putting them on an equal basis. Details on how this matter was approached and finally established are very interesting, but beyond the scope of this article.

There were some municipally owned public utilities which were being "milked" of some of their funds by the local governments, and some utility officials themselves permitted surplus funds to be used by local governments. This brought up the problem of fixing a maximum limit on how much the municipally owned utility should pay to the local government, resulting in the following tax formula:

1. The assessed value of the utility plant is determined by using the gross book value of the plant as of January 1 of the year in which the assessment is to be made.

2. Added to this figure is the value of the materials and supplies on hand as of the same date.

3. The ratio of assessed value to true value is applied, as reported in the statistical report to the governing board of the county in which the municipality is located, submitted by the supervisor of assessments under the direction of the Wisconsin Department of Taxation.

4. If the utility owns property outside of the corporate limits of the municipality, these amounts are excluded in computing the value of the plant for tax purposes.

5. To the above resultant amount, the local municipal government and school tax rate is applied, thus completing the dollar value of the tax.

6. If a tax equivalent greater than that obtained by the above method is desired, the local municipally owned public utility and the local government must obtain written approval from the Public Service Commission of Wisconsin.

These rules, applying to all municipal utilities, were placed in effect on Jan. 1, 1957.

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The parts used to repair this meter at its last overhaul are identical to those used in the latest Trident meters. They embody every thoroughly tested advancement known to the science of metering.

Designing modern parts to fit "old" meters has been a rigid Neptune policy for over 50 years. It is just one of the extra advantages that make Tridents a better buy . . . both for today and for the years to come.

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Branch Offices in Principal American and Canadian Cities.

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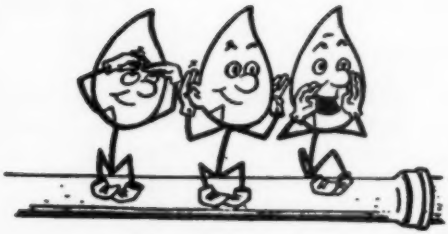

Percolation and Runoff

Down with 'water superintendent'! We want "manager," or "director," or "engineer in charge," or something equally proper and befitting the man who has the health and comfort of the whole community in his care. After all, "superintendent" ain't what it used to be as a designation of status. Around the New York metropolitan area, it is much more likely to suggest the janitor of a condemned tenement than, for instance, the administrative officer of a school system. And elsewhere, too, a "superintendent" sounds a poor relation in his dealings with the general manager of the electric utility, the director of the health department, or even the *vice*-presidents at the bank. Of course, he only sounds less important—but sounds such as these have a way of putting people in their improper place to those who know no better—or even, often, to those who do. Thus, in our mind, does "bank cashier" conjure up an image of gum-chewing Mamie at Cindy's Snack Shop—and rate accordingly. In his struggle for public appreciation and support, the water utility executive cannot afford to pass up any line of attack—and semantics is certainly a line which fronts on the public mind. As a matter of fact, we have an idea that it could be the key to some unconscious classification system which places the salary of a manager or director in a higher bracket than the pay of a superintendent. Up, we say, with the water utility executive! Up with his pay and his status! And, because it isn't on the up and up, down with "superintendent"!

Down, too, while we're about it, with "the water works," that place that New Yorkers can't pronounce and that toomanywhere carries skid row implications. Water works are all over the place anyway, under the streets as well as above them, outside as well as in—the facilities by which water is collected, treated, and distributed. Thus, "the water works," specifically, is the water treatment plant or the water pumping station or, possibly, the water utility business office—water works, yes, but not "*the* water works." That's down where the superintendent is!

Not OEWWA, but ONEWWA it is now—not "Old England," that is, but an "Old" New England Water Works Association, our old friends to the northeast having just joined the ranks of senior septuagenarians with the completion of their Diamond Jubilee convention in Boston last Sep. 18. As the jubileeery has still to take place as of this writing, we are a little handicapped in reporting the details. We can be quite authoritative, though, in noting that AWWA, through Executive Committee action, did extend fra-

(Continued on page 40 P&R)

(Continued from page 39 P&R)

ternal greetings to its sister society as well as congratulations on the fact that "throughout its long history, NEWWA has contributed greatly to the advancement of public water supply and the recognition by the public of dependable water service." And if that seems to make AWWA the brother and NEWWA the sister, so much the happier, for both organizations have long worked together toward the same ends as members of the water works family.

As a matter of fact, not ONEWWA, but VNEWWA, for it is really venerability rather than old age into which we mean to welcome our old New English confreres.

The American Public Power Assn. announces the election of Owen W. Hurd, Kennewick, Wash., as president, succeeding William S. Peterson, Los Angeles. S. T. Anderson, Springfield, Ill., and Mark Whitaker, Knoxville, Tenn., are the new first vice-president and executive vice-president, respectively.

George H. Straub, superintendent of the Westchester Joint Water Works, Mamaroneck, N.Y., was inducted as president of the Mamaroneck Club of Rotary International on Jul. 1.

Lyman D. Warner was recently appointed manager of subsidiaries, including Canadian and foreign activities, for Dresser Mfg. Div., Bradford, Pa. He was formerly assistant to the general manager.

The Technical Advisory Committee on Coagulant Aids for Water Treatment, US Public Health Service, held its first meeting Aug. 30 to establish operating procedures and policies for carrying out its work. Committee members are: Herbert E. Stokinger, USPHS, Cincinnati, Ohio (chairman); A. P. Black, Univ. of Florida, Gainesville; David W. Fassett, Eastman Kodak Co., Rochester, N.Y.; Paul D. Haney, Black & Veatch, Kansas City, Mo.; Robert A. Kehoe, Kettering Lab. of Applied Physiology, Cincinnati; and Richard L. Woodward, USPHS, Cincinnati (secretary).

The group's function is to receive information from producers and purveyors about the composition and toxicity of coagulant aids, to review such information, and to advise the assistant surgeon general, chief engineer, of the Public Health Service as to the safety of these coagulant aids for use in treating drinking water. Recommendations of the committee will be utilized by the Public Health Service in carrying out its statutory responsibility in the field of public water supplies.

Major manufacturers of coagulant aids have been notified of the committee's formation and will be invited to submit information on their products. Further details can be obtained from the Secretary of the Committee, c/o R. A. Taft Sanitary Engineering Center, 4676 Columbia Pkwy., Cincinnati 26, Ohio.

The order establishing the committee is quoted below:

Authority—To be established administratively pursuant to Sec. 301 and 311 of the Public Health Service Act (P.L. 410, 78th Congress), as amended.

Purpose—To present technical advice to the chief, Div. of Sanitary Engineering Services. Conclusions of the Committee to be made available to the American Water Works Assn., members of the water works profession, state and other public authorities, and individuals having responsibilities in the field of water supply.

(Continued on page 42 P&R)

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INCORPORATED

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WATER, SEWAGE AND WASTE TREATING EQUIPMENT SINCE 1894

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TO THE MAN RESPONSIBLE:

- for MUNICIPAL WATER TREATMENT
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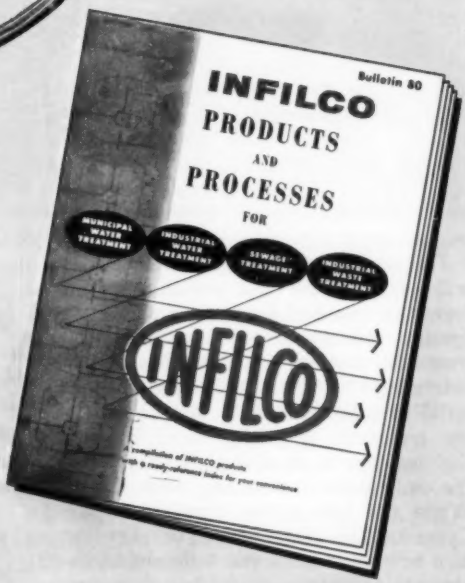

INFILCO announces a NEW CATALOG, to help you select equipment for your water and waste treatment applications.

Cross-indexed for quick, easy reference to equipment, trade names and applications, this 32-page catalog covers all major equipment in the complete INFILCO line. It provides a source of valuable information for you and your engineers.

Write for Bulletin 80, or contact our nearest field office.

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THE ONLY COMPANY impartially offering equipment for ALL types of water and waste processing-coagulation, precipitation, sedimentation, flotation, filtration, aeration, ion exchange and biological treatment

Field offices throughout the United States and in foreign countries

57691-A

(*Continued from page 40 P&R*)

Structure—Consists of five members and a secretary, appointed by the chief, Div. of Sanitary Engineering Services, for a term of 3 years. One of the members, designated by the chief, Div. of Sanitary Engineering Services, is to serve as chairman. Members are to include federal and nonfederal representation recognized as possessing expert knowledge of water works technology, water supply chemistry, and toxicology. Close consultation will be maintained with representatives of the American Water Works Assn.

Function—The first function of the Committee will be to receive from producers and purveyors information concerning the composition and characteristics of new coagulant aids proposed for use in the treatment of public water supplies. The information submitted will include data relative to the proposed use of the material for water purification, methods of application, recommended dosage, etc. The information will also include data relative to the toxicological, chemical, and physical properties of such substances. The Committee through its secretary will give assurance of the confidentiality of such information submitted to it as may be requested by the producer or purveyor.

The second function of the Committee will be to review and evaluate the information received by it with respect to specific materials proposed for use in the treatment of public water supplies, and to determine whether, in its opinion, the material in question may be safely used for the treatment of public water supplies without adverse physiological effect upon the individuals consuming such water. When the information provided to the Committee by the producer or purveyor of a new material is not sufficient to enable the Committee to reach a firm conclusion, the Committee through its secretary shall so inform the producer or purveyor of the material.

The third function of the Committee will be to report to the chief, Div. of Sanitary Engineering Services, the conclusions reached following evaluation of the information relating to each material, advising him either that (a) the material is safe for the proposed use, or (b) unsafe for the proposed use.

Meetings—The Committee will meet at the call of the chief, Div. of Sanitary Engineering Services, or of the Committee chairman as may be necessary to carry out its functions.

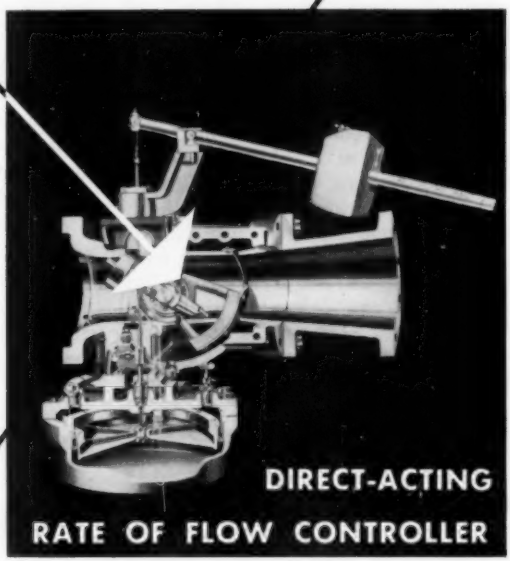
For the birds, in the past few San Francisco Water Department budgets, there has been an item of $9 per annum. This is expended for grain to feed friendly blackbirds on department property at Sunol, Calif. This year when the birds arrived on schedule for their handout they found hordes of grasshoppers devouring the leaves of walnut trees planted on the Sunol grounds. That, of course, went against their grain—so the blackbirds fed on the grasshoppers and saved the department the $1,000 it planned to spend on insecticides to get rid of them. Even if the feeding program has been going on for 10 years, a $1,000 return on a $90 investment sounds mighty good these days. Buy, buy blackbirds!

Alex F. Fino has been appointed chief engineer of Hammond Iron Works. He has been with the company since 1940 and has had the principal responsibility for the design and development of various Hammond products.

Naaman Rhoades has been named manager of Keasbey & Mattison's asbesto-cement pipe factory at St. Louis, Mo. He was formerly assistant works manager there. The St. Louis plant capacity is being doubled to make it the company's most important factory.

(*Continued on page 44 P&R*)

Exclusive!



LOW FRICTION MEANS ACCURATE, DEPENDABLE, TROUBLE-FREE OPERATION!

All Friction Points of this Controller equipped with Ball Bearings or Knife Edges!!

This completely self-powered rate of flow controller, designed especially for waterworks use, offers the highest sustained accuracy throughout its maintenance-free life because of design features which include:

- Low friction design
- Packless construction
- Liberal use of corrosive resistant materials
- And many other unique design advantages

REQUEST Bulletin 600-G6A for complete details. Write **Builders-Providence, Inc., 365 Harris Ave., Providence, R. I.**

BUILDERS-PROVIDENCE
DIVISION OF
B-I-F INDUSTRIES
METERS FEEDERS CONTROLS

(*Continued from page 42 P&R*)

Unintelligibility, a quality with which James Joyce's works have long been stigmatized, seems suddenly a most inappropriate characterization—suddenly, we say, because that is how we happened upon this description of "waterlover, drawer of water, watercarrier" Leopold Bloom, "hero" of *Ulysses,* turning on the faucet to draw water for a shave:

Did it flow?

Yes. From Roundwood Reservoir in county Wicklow of a cubic capacity of 2,400 million gallons, percolating through a subterranean aqueduct of filtre mains of single and double pipeage constructed at an initial plant cost of £5 per linear yard by way of the Dargle, Rathdown, Glen of the Downs, and Callowhill to the 26-acre reservoir at Stillorgan, a distance of 22 statute miles, and thence, through a system of relieving tanks, by a gradient of 250 feet to the city boundary at Eustace Bridge, upper Leeson Street, though from prolonged summer drouth and daily supply of 12½ million gallons the water had fallen below the sill of the overflow weir for which reason the borough surveyor and waterworks engineer, Mr. Spencer Harty, C.E., on the instructions of the waterworks committee, had prohibited the use of municipal water for purposes other than those of consumption (envisaging the possibility of recourse being had to the impotable water of the Grand and Royal canals as in 1893) particularly as the South Dublin Guardians, notwithstanding their ration of 15 gallons per day per pauper supplied through a 6-inch meter had been convicted of wastage of 20,000 gallons per night by a reading of their meter on the affirmation of the law agent of the corporation, Mr. Ignatius Rice, solicitor, thereby acting to the detriment of another section of the public, selfsupporting taxpayers, solvent, sound.

all of which is certainly entirely intelligible and, considering the fact that the description was written sometime between 1914 and 1918 (the book having been first published in 1920), most illuminating in indicating the water conservation measures then applied, as well as recording the basic statistics of the Dublin water system, manifesting the type of attention to detail that brought Joyce the accusation of prurience for his similarly thorough analyses of activities thought generally to be rather more, not personal, but private than drawing water for a shave. Unintelligible, though? No!

A demand charge on nonconserved air conditioner water is contemplated by Milwaukee, Wis., provided the State Public Service Commission approves. The city plans to charge $20 a year per ton of refrigeration (above 3 tons), in order to encourage the installation of conservation devices and thus reduce summer peak loads.

Lynn M. Miller has resigned from the Michigan Geological Survey to join the staff of Jones, Henry & Williams, consulting engineers, Toledo, Ohio.

Paul D. Cook has resigned as Painesville, Ohio, city manager to accept the position of general manager with Upson Machine Products, Inc., Painesville.

Gerald T. Hughart has been named general manager of Klemp Metal Grating Corp., Chicago. Mr. Hughart was formerly manager of manufacturing for Stearns-Rogers Mfg. Co., Denver.

William A. Schubert has been named engineer-in-charge of rotary compressor sales for Allis-Chalmers Mfg. Co. He has been with the firm since 1937.

(*Continued on page 46 P&R*)

HOW HIGH IS HIGH?

We are being pressed everyday by engineers to take a position on highness, i.e., highness of throughput rate in cold process clarification and softening plants. The facts are that the Graver solids-contact Reactivator® can operate and has operated successfully at rates of flow of 2.0—2.5 gpm/sq. ft. on various water supplies. However, we generally recommend that plant and consulting engineers design such units to meet specific conditions and at more conservative flow rates, allowing for reserve capacity to accommodate changes in operating conditions, demands for increased flow or changes in water composition and temperature. We believe this to be sound engineering practice — a belief that has been borne out in hundreds of successfully operating Reactivator installations treating a variety of raw water supplies. Our policy on this subject is outlined in Technical Reprint T-135. Write for a copy to: Municipal Dept. M-212, Graver Water Conditioning Co., Division of Graver Tank & Mfg. Co., Inc., 216 West 14th Street, New York 11, New York.

(*Continued from page 44 P&R*)

Drink up! is the word you can give to all the fat-fearing fellows and females in your service area, for it is now official—water is NOT fattening. It was the American Dietetic Assn., basing its conclusions "not only on its own extensive researches but also on those of the Bureau of Investigation of the American Medical Assn., the US Dept. of Agriculture, the Federal Pure Food and Drug Administration, and the Federal Trade Commission," that finally gave us a convincingly authoritative statement on the subject to lay the ghost of bloated tissue. This bit of debunking is part of a whole bookful of myth-shattering data, entitled *Food Facts Talk Back*. Not many more of the facts are of particular interest to water works men as water works men, but certainly water works men as martini drinkers will be interested in the fact that olives do not increase sexual potency and perhaps that the craving for certain food or drink does not mean that the body requires it. At any rate, the fact that water is not fattening should certainly be a boon to public good will, so drink up!

Murder, arson, rape, and other forms of trouble or dishonesty seem to dominate the nation's headlines. The only water works news that stands a chance of major attention is the news of crises or crime. Thus, the drought and an occasional major breakdown would be doing the whole job of trying to keep water on the front page were it not for the assists of a crackpot here and there. It was certainly a crackpot in San Francisco in June who made national water supply news by stealing hydrants—eight of them in a few days—from the site of a wartime housing project. And he who in Oneonta, N.Y., in July, made off with 262,000 gal of water from the municipal swimming pool without access to the drainage valves must have been either slightly cracked or entirely publicity agent. Finally, in Santa Barbara, Calif., in August, the extortionist who threatened to poison the city's water supply with *Botulinum* toxin if he didn't receive $25,000 was certainly not all, or even at all, there—at least when the FBI, the local police, and special armed guards closed in on the payoff rendezvous.

Although it probably is true that even bad notices are better than none at all, it does seem a shame that we must put our worst foot forward to push into the limelight. We once thought "there'll come a day," but it seems already to have come and gone, just about unnoticed. That was Aug. 18, the day when Charlie Roche, Chicago water distribution system foreman, rated almost a half-column in the New York *Times*. It was Charlie who, while out on a leak hunt, picked up a wallet containing $810, mailed it back to the owner, a New York City dress salesman, and then refused to accept any reward. As a matter of fact, it's almost as sad to find honesty so rare as to rate such attention as it is to find that dishonesty is so newsworthy. All of which makes us stick to the sports pages where, between the tales of crooked fights, doped horses, thrown basketball games, and cartel baseball, we, as a Yankee fan, can at least find a happy story in the standings.

Robertson Sillars has been named manager of the Publications Bureau of the Portland Cement Assn. He succeeds J. L. Schneider, who will devote full time to his duties as assistant secretary of the association.

(*Continued on page 50 P&R*)

SAVE SPACE – SAVE COSTS

AWWA 48", 125# valve for drop-tight shut-off at 100 psi. Renewable rubber seat; hydraulic cylinder operator.

AWWA 60", 50# valve for drop-tight shut-off at 35 psi water pressure. Cast iron body with spool type rubber liner; with worm gear and handwheel operator.

with

W. S. ROCKWELL

Butterfly Valves

Built to Meet All AWWA Specifications

- Compact—Lighter Weight
- Reduced Installation Space
- Lowest Installed Cost
- Efficient Reliable Operation
- Drop-Tight Shutoff
- Minimum Restriction to Flow
- Minimum Pressure Drop
- Non-Clogging
- Better Control—Manual or Automatic
- Less Maintenance

W. S. Rockwell Butterfly Valves are made in all standard sizes of cast iron, cast steel, stainless steel, bronze or other alloys; natural or synthetic gum rubber seat with clamping segments, or spool type rubber liner extending over flange faces. Operators—manual: AWWA nut, handwheel, chain wheel or other types; automatic: electric motor or cylinder. Write for Bulletin 574.

ROCKWELL SINCE 1888 BUILT

W. S. ROCKWELL COMPANY

2607 Eliot Street — Fairfield, Connecticut

"DON'T DRINK THAT!"

It's poison!
Polluted water not only endangers your life . . . it costs you money as well. Local pollution compels many communities to travel too far for drinkable water . . . and taxes climb.
If industry, our second greatest user, must purify water *before* using it, production costs soar. You pay more for goods.
Pollution robs you of your fun too . . . ruins fishing, swimming, boating.
Water officials ask your help in preventing pollution and solving other problems.

1. Encourage future water planning.
2. Support realistic water rates and water supply bond issues.
3. Conserve water where you can.

Water today is everyone's business!

PROOF POSITIVE
CAST IRON PIPE SAVES
YOU TAX DOLLARS

This cast iron water main laid in Richmond in 1833 is still in excellent condition. Such performance is typical of many century old cast iron water and gas mains still serving throughout America.
Small wonder that where long life, dependability and economy are "musts," water officials prefer cast iron pipe . . . No. 1 Tax Saver!

CAST IRON PIPE
RESEARCH ASSOCIATION SUITE 3440, PRUDENTIAL PLAZA, CHICAGO 1, ILL.

MODERNIZED cast iron

POLLUTION IS ONLY ONE OF YOUR PROBLEMS

Your biggest problem today, probably, is to make the public aware there *is* a water problem.

Advertisements like the one at the left . . . one of our continuing campaign on conservation* . . . do exactly that.

Not only do they dramatize our current water crisis; they stress the need for public cooperation and support for all water programs.

That continuing education makes your job easier.

CAST IRON

Cast Iron Pipe Research Association, Thos. F. Wolfe, Managing Director, Suite 3440, Prudential Plaza, Chicago 1, Ill.

**Appearing in:* Saturday Evening Post, Newsweek, U. S. News and World Report, Nation's Business.

npipe FOR MODERN WATER WORKS

(Continued from page 46 P&R)

Sparling Meter Co. is constructing an addition to its El Monte, Calif., plant, in order to consolidate its Los Angeles and El Monte factories. Completion is expected this fall, after which the move from Los Angeles will take place.

'Hurry up and wait' has long been the soldier's thumbnail sketch of life in the army—and just how long the wait can be was indicated last July in Lancaster, Pa., when the Army finally pinned a Silver Star for bravery on the chest of Sergeant Robert E. Deets. Actually, by then it was former Sergeant Deets—and plenty former, too, for it was in 1918 at Chateau-Thierry that he performed his heroics, leading a patrol of eight men in an almost suicide action to protect a withdrawal of troops. By the time the recommendation for his decoration emerged from the files, where it had been "lost," Bob was performing his heroics on the water front instead, as an inspector for the Lancaster Water Dept.—still, however, protecting withdrawals. Such is the stuff of which heroes are unmade!

Chicago Bridge & Iron Co. announces the appointment of Fred L. Goldsby, vice-president and formerly general sales manager, as assistant to the president. S. C. Hamilton has been named vice-president and general sales manager. He is succeeded as Houston, Tex., district sales manager by K. W. Lange.

(Continued on page 52 P&R)

IRON REMOVAL & WATER SOFTENING

During 1956 we built a large number of durable and efficient low cost water treating plants for the removal of iron, manganese, hardness and other undesirable impurities. These plants operate *automatically*, require very little space and are unusually inexpensive to operate and maintain.

Full Particulars on Request

HUNGERFORD & TERRY, INC.

CLAYTON 5, NEW JERSEY

Photo courtesy of Mr. W. K. Sanders, Superintendent, Water and Light Department, Morrisville, Vermont

62 YEARS' PERFECT SERVICE

. . . and ready for 62 MORE!

EDDY

VALVES AND HYDRANTS

Morrisville, Vermont, installed the above EDDY Valve in a water main way back in 1895. When uncovered recently, it was working perfectly, needing only an easily obtained, easily installed packing to restore it to 100% efficiency.

On the basis of Eddy's long time record of continuous availability of replacement parts—and in the light of innumerable cases where EDDY valves and hydrants have served perfectly, needing no maintenance, for 20, 40, 60 years and longer—we feel justified in predicting *another* 62 years' service for the valve shown here.

Interested in such service for *your* system? Then we invite your inquiry TODAY!

Eddy Hydrants and Valves meet all AWWA standards and are available to fit any existing or planned installation.

Send today for full data on the complete line of Eddy Valves, Hydrants and other waterworks' necessities. No obligation.

EDDY VALVE COMPANY

A Subsidiary of James B. Clow & Sons Inc.

WATERFORD, NEW YORK

(*Continued from page 50 P&R*)

William H. Cochrane has been appointed executive vice-president of Neptune Meter Co., N.Y. He fills a newly created office established to improve coordination between the parent organization and its many subsidiaries. Prior to joining Neptune, Mr. Cochrane was general manager of the Industrial Div. of Lever Brothers Co.

Bamby L. Soscia has accepted the post of project engineer with Builders-Providence, Inc., division of B-I-F Industries, Inc., Providence, R.I.

Joint administration of water and sewer facilities seems to be receiving widespread attention these days. Not only has our own AWWA Committee 4430 M been laboring long on a survey of the problems involved, but as far away as Iran, the subject was recently assigned for study to a special committee of the Majlis—Iran's national assembly. It is not yet known whether the thinking of the AWWA group—soon to be reported in this JOURNAL—has been quite as elemental as that of the Iranian investigators, even though the primary motives of greater efficiency and lower cost have been identical. It may be expected that Co-Chairmen Len Thompson and Bob McLeod have directed the considerations of their committee primarily to the operations phase of the two services involved, whereas Chairman Akemi of the Iranian investigators has gone back to the essentials with a proposal that would virtually halve the initial investment in these services.

It was as a conscientious assemblyman allergic to foreign exploitation that Chairman Akemi saw, and called to the attention of the Majlis, subtle machinations of foreign interests behind a contract to lay pipe in the city of Tabriz: "They propose to lay two sets of pipe, one containing drinking water, the other sewage and waste," he reported. "I pointed out that one set was ample; water could be pumped through them by day and the waste by night. No one wants water when he's asleep. . . . Two sets of pipe indeed; what fools do they take us for!"

Pipelaying was suspended with the appointment of Akemi and his committee of investigators, but as the date of that action was not reported, we have no idea whether the Tabrizian system is now in suspense or exploitatory or Akemically pure. Meanwhile, watch the JOURNAL text pages for the enjoinings of 4430 M!

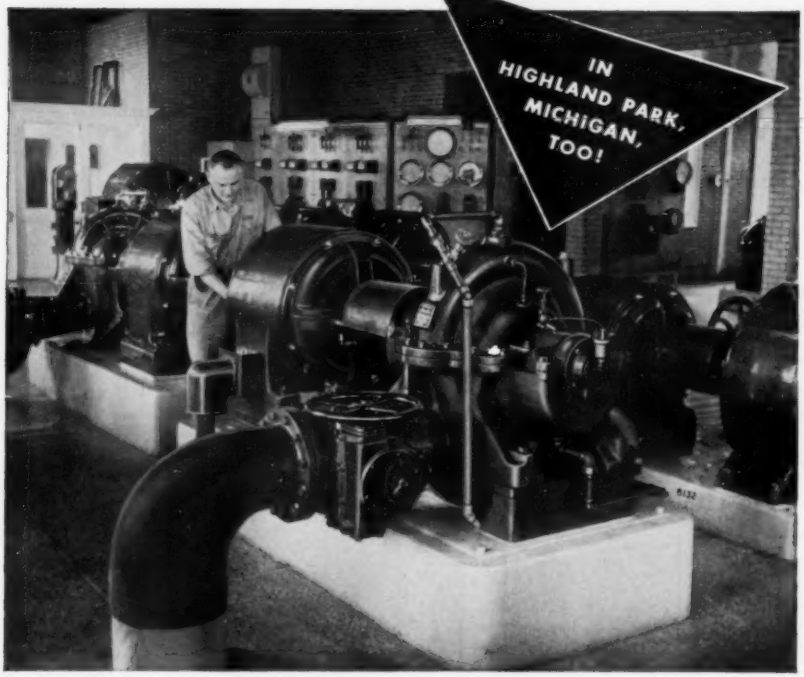
Everett W. Lundy is the new general sales manager of Peerless Pump Div., Food Machinery & Chemical Corp. Mr. Lundy, previously assistant sales manager, succeeds B. A. Tucker, who has retired.

Orangeburg Mfg. Co. has acquired a 3½-acre plant site and manufacturing facilities in Marion, Ind., in order to expand its production of plastic pipe. The new plant will supplement the firm's main factory at Orangeburg, N.Y.

S. Morgan Smith Co. has moved all its valve operations from Philadelphia to the firm's main plant in York, Pa. In addition to increasing production facilities, the move is expected to lower manufacturing costs and shorten delivery time.

(*Continued on page 56 P&R*)

DE LAVAL pumps America's water...



The photograph shows a De Laval centrifugal pump on line at the Davison and Dequindre pumping station of the Highland Park, Michigan Water Works. The Highland Park Water Works has eight De Laval motor driven units, with a total capacity of over 50 million gallons per day in service at the above station and at their high lift station on Lake St. Clair, which pumps raw water 11.6 miles to their purification plant. According to the user, all eight pumps have given excellent performance in year-round service.

Write for your copy of new De Laval Bulletins 1004 and 1005 giving data on these pumps.

MR. T. L. DUNKIRK
City Engineer

MR. V. L. HINEBROOK
Superintendent of Water Department

MR. W. L. WELTER
Asst. Superintendent Water Department

DE LAVAL *Centrifugal Pumps*

DE LAVAL STEAM TURBINE COMPANY
822 Nottingham Way, Trenton 2, New Jersey

DL-303A

SEND FOR CATALOG 164
CATALOG 164
SMS
S. MORGAN SMITH
COMPLETE VALVE & REMOTE CONTROL SYSTEM

Now SMS Introduces A New Concept in

VALVE REMOTE CONTROL SYSTEMS

Here, for the first time, is a complete valve and remote control system — now offered as a "packaged" unit by S. Morgan Smith Co. It is designed to satisfy two basic applications, either singly or in combination:

Where you need precise positioning and indication.
Where you need remote control.

The system is made up of three elements: an SMS-Rotovalve or R-S Butterfly Valve, a "packaged" hydraulic positioner or electric motor operator installed next to the valve, and a master remote control and indicator unit, that may be located anywhere from a few hundred yards to many miles away.

For either modernization or new construction, this system makes possible savings in supervisory costs at remote stations, gives better operating control, and increases pumping efficiency. It is suited to:

Pressure control
Flow control
Pump check service
Throttling on a pump
Reservoir control
Altitude control
Sump level control
Effluent control
Filter water influent level control

To obtain full information on the completely new SMS valve and remote control system, ask for Catalog 164. It is available without charge through any of our representatives, or you may write to S. Morgan Smith Company, York, Penna.

On the West Coast—see this new system in operation at San Jose Civic Auditorium, October 30 to November 1, in the SMS Booth at the California Water Works Show.

S. MORGAN SMITH HYDRODYNAMICS

AFFILIATE: S. MORGAN SMITH, CANADA, LIMITED, TORONTO

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(*Continued from page 52 P&R*)

Our Miss America—much as we were taken with Marilyn Elaine Van Derbur and her perspicacity in the matter of who wears the pants in the family—has to be Ann Marie Caldrone of Chicago. We haven't seen Ann Marie in a bathing suit; as a matter fact our only glimpse of her at all has been in a newspaper portrait. Even sight unseen, though, we've made our choice, for before the same sort of inquisition as Marilyn Elaine, Ann Marie came through with even flyinger colors. It was the Chicago *Tribune*'s Inquiring Camera Girl who put the question: "Of all modern conveniences, which affords you the greatest pleasure?" And it was Ann Marie among the five girls questioned who put the others' automobile, typewriter, steam iron, and television set to shame with: I think hot and cold running water is the greatest convenience because of how easy it makes cooking, housekeeping, cleanliness, and innumerable household chores. I'd hate to have to pump it all.

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(*Continued on page 96 P&R*)

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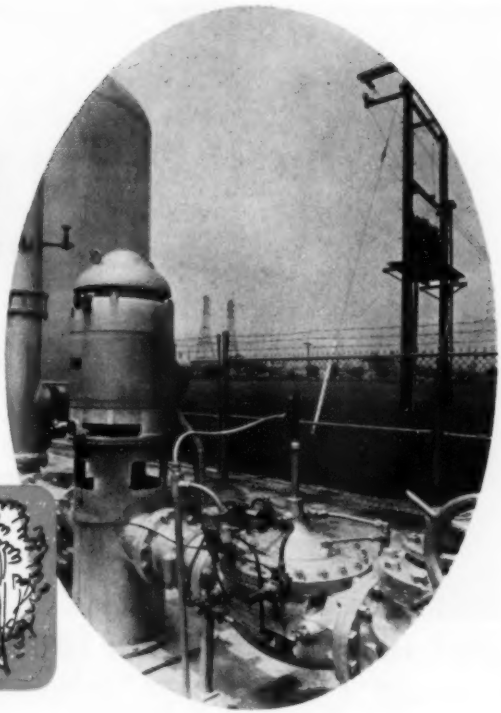

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Key: In the reference to the publication in which the abstracted article appears, 39:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

CHEMICAL ANALYSIS

Determination of Trace Amounts of Alkyl Benzenesulfonates in Water. E. M. Sallee, J. D. Fairing, R. W. Hess, Ralph House, P. M. Maxwell, F. W. Melpolder, F. M. Middleton, J. Ross, W. C. Woelfel, & P. J. Weaver. Anal. Chem., **28**:1822 ('56). Infrared method presented is lengthy, and it is possible that few labs. engaged in routine water anals. will have necessary equipt. It does, however, for first time, permit accurate specific detn. of alkyl benzenesulfonate (ABS) in water. For these reasons, method will find its greatest use in running referee anals. and checking accuracy of proposed short methods. Steps in method and principles behind each can be summarized as follows: [1] Absorption of ABS on activated carbon. (This concs. ABS and separates it from many interferences. Technique quantitatively collects ABS from concns. as low as few ppb.) [2] Desorption from carbon with alkaline benzenemethanol. (At least 95% of ABS can be recovered in this manner.) [3] Acid hydrolysis. (This destroys interferences such as org. sulfates, phosphates, and other hydrolyzable substances.) [4] Petroleum ether wash. (Hydrocarbons, alcohols, and sterols are among materials removed by petroleum ether extraction from alkaline soln.) [5] Amine extraction. (ABS is quantitatively extracted in chloroform as complex of 1-methylheptylamine, and, thus, is separated from inorg. salts and water-sol. org. material.) [6] Infrared detn. (Infrared examn. after evapn. of chloroform shows nearly pure ABS-amine complex remaining. Carbon tetrachloride or carbon disulfide soln. of this residue can be used for quant. detn. by measuring absorption at 9.6 and 9.9 μ.)—*PHEA*

Spectrophotometric Determination of Alkyl Benzenesulfonate Detergents in Surface Water and Sewage. J. D. Fairing & F. R. Short. Anal. Chem., **28**:1827 ('56). Method has been developed for detn. of alkyl benzenesulfonates, based on isolation of benzenesulfonate from interfering ions by solvent extractions of its 1-methylheptylamine salt, and measurement of isolated benzenesulfonate by an improved methylene blue method. Detailed procedure for method, which involves amine-chloroform extraction, acid hydrolysis, and amine-hexane extraction, in that order, is given. It can be used to det. less than 0.01 ppm in water and 0.50 ppm in sewage, and it is not subject to any known interference from materials likely to be present in surface waters or sewage.—*WPA*

Use of the Photo-Colorimetric Method for the Determination of Very Small Amounts of Ammonia-Nitrogen in Water. J. Kucharski. Przemyl. Chem. (Pol.), **7**:734 ('51). Author shows that in detn. of small amts. of ammonia-nitrogen in natural waters with Pulfrich photo-colorimeter and Nessler's reagent, absorption is not proportional to amt. of nitrogen. Variations from Beer's law are ascribed to varying content of chlorine in sea water. Author describes development of method using Lange colorimeter with multiflex galvanometer and current stabilizer. With insertion of iris diaphragm before one of photo cells, sensitivity of galvanometer scale was greatly increased. Method and results are discussed.—*WPA*

Microchemical Determination of Calcium in Natural Waters. F. P. Gorbenko. Gidrokhim. Materialy (USSR), **24**:36 ('55). Conditions for microvolumetric detn. of Ca by the NnO_4^- method were studied for application to water anal. Ppt. the Ca^{++} with $(NH_4)_2C_2O_4$ at pH 6.2, wash the ppt. 4 times with a satd. CaC_2O_4 soln., centrifuge, dissolve the ppt. with 1 ml 8% H_2SO_4 soln., and titrate with 0.01 *N* $KMnO_4$ soln. until appearance of pink tint. Compare color of sample with standard set prepd. from basic

(*Continued on page 70 P&R*)

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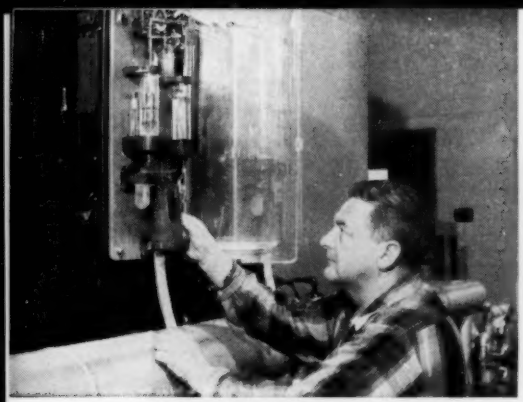

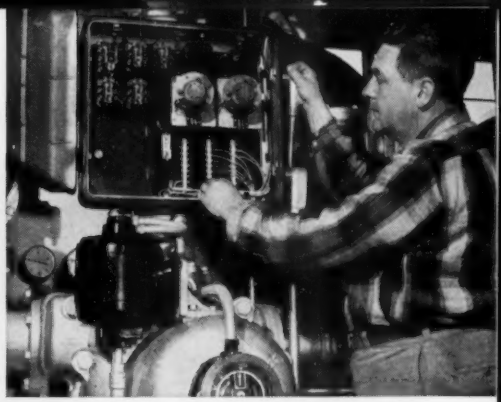

HARDNESS TESTER (left) initiates regeneration by Automatic Controls (right). This new Permutit plant, with Q resin, softens 72% more water—using same manpower, less salt! E. Aurora, N. Y. Village Eng.: *E. J. Maurer.*

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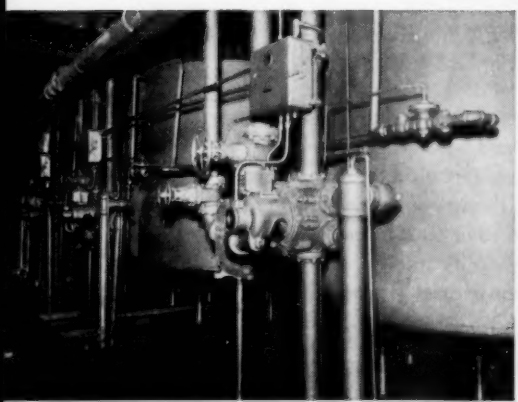
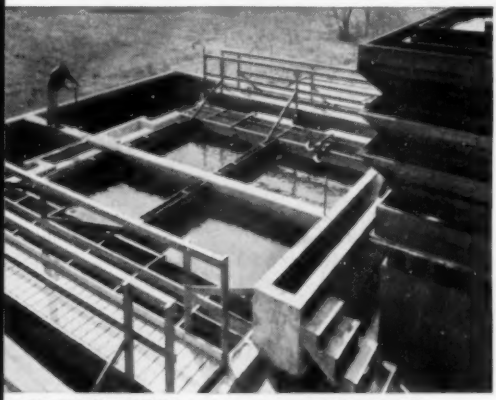


SOFTENER CAPACITY TRIPLED and $7,000 yearly saved on salt by change from zeolite to Permutit Q. Normal, Ill. Cons. Eng.: *Farnsworth & Conley.*

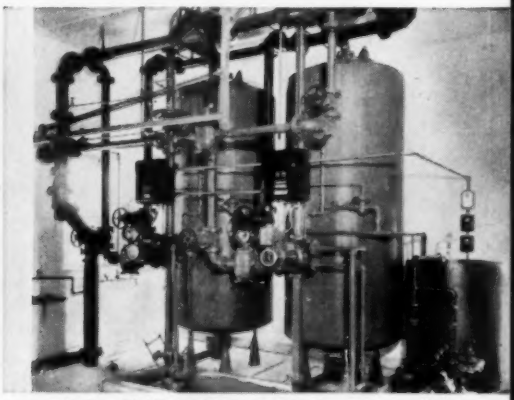
TRIPLE TROUBLE! 275 ppm hardness, 200 ppm alkalinity, 3 ppm iron are reduced by this Precipitator. Staples, Minnesota. Supt.: *E. H. Klang.*

TURBIDITY gets cut from 1500 to less than 5 ppm in this Precipitator. Mt. Carmel, Ill. Cons. Eng.: *Warren & Van Praag, Inc.*

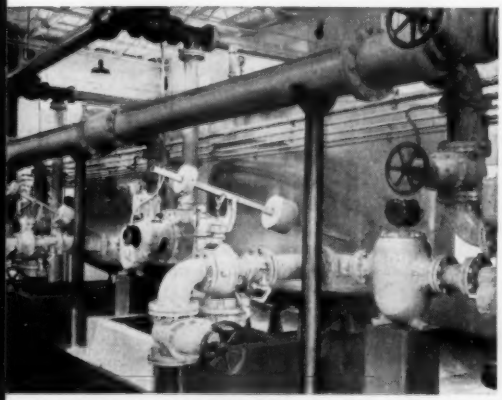
SEA WATER saves $32,980 per year over salt for regenerating Softeners. Hollywood, Fla. Cons. Eng.: *Reynolds, Smith & Hills.*



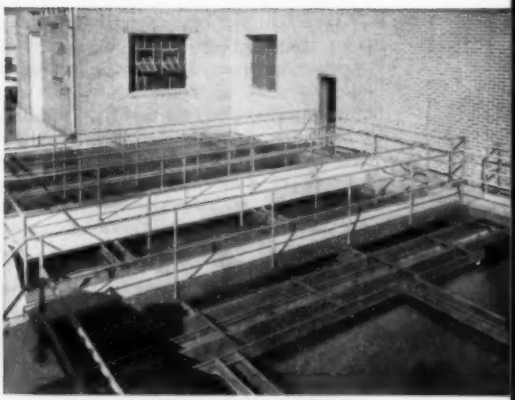
30 PPM IRON gets cut to 0.14 ppm in Aerator and Precipitator . . . even before filtration! Fairless Hills, Pa. Cons. Eng.: *H. H. Le Van, Jr.*



269 PPM HARDNESS is removed by these automatic Softeners. Aerator and Filters cut iron. Martinsville, Ill. Supt.: *O. Wiser.*



AUTOMATIC CONTROLS backwash, regenerate, rinse and return Softeners to service. New Smyrna Beach, Fla. Cons. Eng.: *Russell & Axon.*



OLD SETTLING BASINS house these modern Precipitators that boost capacity. North Kansas City, Mo. Cons. Eng.: *C. A. Haskins.*

(*Continued from page 66 P&R*)

fuchsin. Ca can be detd. with error less than 1–2% in amts. of 0.01–0.4 mg. Up to 500 mg/l Fe^{++} does not interfere.—*CA*

The Determination of Calcium in Rain Water. I. DAVIES & G. HOPKINSON. Analyst (Br.), **81**:551 ('56). Ca in samples of rain water collected in London area was detd. by standard method, by use of EDTA, and by flame photometry; brief descriptions of latter methods are given. Comparison of results shows that either method gives results within accuracy of sampling error of rain gauge, and that flame photometric method is closer to standard method.—*WPA*

Complexometric Determination of Calcium and Magnesium in Water. R. CERVENKA & M. KORBOVA. Chem. Listy (Czech.), **50**:306 ('56). Ca is titrated with an aq. soln. of the di-Na salt of ethylenediaminetetraacetic acid (I) (13.27 g/l water) with minimal amt. of murexide as indicator. The number of ml gives directly German degrees of Ca hardness. After acidifying with NHCl and adding buffer soln. contg. 54 g NH_4Cl and 350 ml 25% NH_4OH in 1 liter, Mg is detd. in same sample with I and Eriochrome Black T. The number of ml gives Mg hardness. Interfering influence of Fe and heavy metals present in waste waters is removed by addn. of KCN or buffer soln. contg. $Na_2B_4O_7 \cdot 10H_2O$ 40, NaOH 10, and Na_2S 5 g/l water.—*PHEA*

Semimicro Method for the Determination of Chloride. P. BLANC, P. BERTRAND, & L. LIANDIER. Chim. Anal. (Fr.), **38**:156 ('56). Speedy and simple nephelometric method for detn. of chloride in range 0–20 mg/l is described. Ppt. obtained by addn. of silver nitrate is maintained in suspension by 20% soln. of Tween-20. After 30 min of frequent agitation at 40°C, turbidity of soln. is measured. Beer's law is obeyed over range studied. Application of method to detn. of chloride in potable and mineral waters, biol. fluids and wines is described. Accuracy of method is said to be comparable with that of volumetric methods.—*WPA*

Direct Spectrophotometric Determination of Small Amounts of Chloride. P. N. WEST & H. COLL. Anal. Chem., **28**:1834 ('56). Direct spectrophotometric method has been developed for detn. of low concns. of chloride, based on use of iron (III) perchlorate. Chloro complexes of iron (III) exhibit intense absorption band in vicinity of 340 mμ. Method can be used to det. chloride in presence of other halides and almost all other common ions, but large amts. of sulfate tend to interfere.—*WPA*

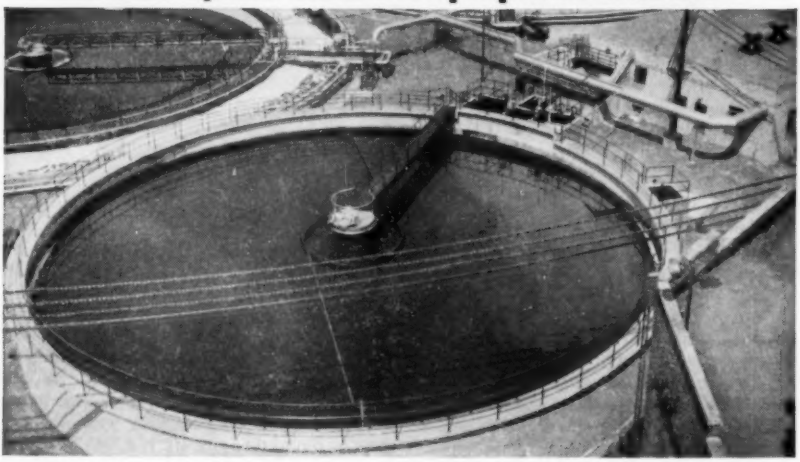
Photometric Determination of Chlorides in Water. D. M. ZALL, D. FISHER & M. Q. GARNER. Anal. Chem., **28**:1665 ('56). Method has been devised for photometric detn. of small amts. of chloride in water. Method is based on displacement of thiocyanate from mercuric thiocyanate by chloride ion and subsequent reaction of liberated thiocyanate with ferric iron to form colored complex $[Fe(SCN)]^{++}$, which is measured either visually or in spectrophotometer. Concns. of chloride as low as 0.05 ppm can be detd.—*PHEA*

Colorimetric Microdetermination of Chloropicrin in Water. R. M. FOURNIER & M. PERSON. Chim. Anal. (Fr.), **39**:155 ('57). Aq. sample contg. 10–40 γ chloropicrin (**I**) is extracted with 100–10° ligroine. 2-ml portion of the extract is mixed with 5 ml freshly prepd. reagent (50 ml pyridine, 50 ml MeOH, 0.6 g KCN, 0.1 g phloroglucinol). After 5 min, color is measured at 535 mμ and amt. of **I** found from calibration curve.—*CA*

Determination of Traces of Copper in Water. M. KOVARIK & V. Z. VINS. Anal. Chem., **147**:401 ('55). Photometric method for estn. of traces of Cu in water is given. By shaking sample with a soln. of lead dietyldithiocarbamate in chloroform, Cu is extracted together with Ag and Hg. Ag and Hg do not interfere. Detailed description of procedure is given. 10 ml of 10% soln. of potassium sodium tartrate and 10 ml of 2 N ammonium chloride soln. are added to 500-ml sample of water and then soln. is made weakly alkaline with aq. ammonia. Soln. is shaken with 10 ml of chloroform soln. of lead diethyldithiocarbamate and yellow to brown layer of copper diethyldithiocarbamate separates. Extinction of copper compd. is measured at 500 mμ in 1-cm cell, using S50 filter. Method makes it possible to det. amts. of Cu from 0.02 μg/ml with relative error of about ±1.5%. Lead diethyldithiocarbamate reagent is prepared by dissolving 0.1 g of lead acetate in water and adding 5 ml of 10% soln. of potassium so-

(*Continued on page 72 P&R*)

Rodney Hunt gates of tough Everdur withstand bleach-plant acid and pulp-mill wastes



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(Continued from page 70 P&R)

dium tartrate. Soln. is made alkaline with 2 N potassium hydroxide soln. and 5 ml of N potassium cyanide solution are introduced to complex traces of Cu and Fe. 0.12 g sodium diethyldithiocarbamate in water is added and ppd lead salt is extracted in 250 ml of chloroform. Org. layer is removed, shaken with water, reseparated, filtered, and made up to 1 liter.—*WPA*

Indirect Flame Photometric Method for Determination of Halides. O. MENIS, H. P. HOUSE & T. C. RAINS. Anal. Chem., **29**: 76 ('57). Indirect flame photometric method has been developed for detn. of chloride, bromide, and iodide. Method is simple and rapid, and is useful when concns. are too low to be detd. satisfactorily by ordinary potentiometric methods. Sample containing halide ion is added to dil. soln. of silver nitrate and, after removal of silver halide by centrifugation, luminosity due to residual Ag is measured at wavelength of 328 mμ. From decrease in luminosity, halide equiv. to Ag removed by pptn. is estimated. By using ammonium hydroxide as masking agent, it is possible to det. bromide in presence of chloride, and iodide in presence of both bromide and chloride. Uranyl, chromate, and phosphate ions, in moderate concns. do not interfere. For solns. containing 0 02 0.20 milliequiv. of halide per liter, precision is ±5%.—*WPA*

Determination of the Different Forms of Iron in Natural Waters. Y. S. SHIDLOVSKAYA-OVCHINNIKOVA. Gidrokhim. Materialy (USSR), **24**:33 ('55). Fe^{++} was detd. colorimetrically by adding 0.1 ml of 0.5% α,α'-bipyridyl in 0.001 N HCl soln. at pH 4 (the buffer soln. consisted of equiv. amt. of 5.5 N AcOH and N AcONa to 10 ml water); 0.5 γ Fe^{++} can be detd. The Fe^{+++} was detd. by adding 2 ml 10% sulfosalicylic acid soln. at pH 4 to 10 ml water and measuring red-violet color obtained; 1 γ Fe^{+++} in 10 ml can be detd. To det. colloidal and complexly bound Fe, 100-50 ml of water, 6 ml 25% H_2SO_4, and 12 ml 0.1 N $KMnO_4$ were boiled in 1.0–1.5 hrs to 15 ml vol., 10 ml, 0.1 N oxalic acid was added, excess oxalic acid removed by $KMnO_4$, and soln. neutralized with 16 ml NaOAc and dild. to 50 ml; to 10-ml aliquot was added 1 ml Na_2SO_3, and Fe detd. colorimetrically.—*CA*

Potentiometric Method for Determining a Number of Metals by Means of EDTA (disodium salt). L. M. BUDANOVA & O. P. PLATONOVA. Fact. Lab. (USSR), **21**:1294 ('55). Examples of direct potentiometric titrations of Pb, Cu, Zn, Ni, Cd, Sn and Mg in ammoniacal soln. with EDTA (disodium salt) and of back-titrations of excess EDTA with lead nitrate soln. are given.—*WPA*

Determination of Nitrate in Pond Water. I. II. H. L. GOLTERMAN. Koninkl. Ned. Akad. Wetenschap., Proc. Ser. B (Neth.), **58**:109 ('55). Detn. of nitrate in pond water with phenoldisulfonic acid and xylenol without clarification was not satisfactory. Cl ions were removed with Ag_2SO_4 after which excess of Ag^+ was removed by passage across ion exchanger. Sulfate coming from Ag_2SO_4 should be removed by $Ba(OH)_2$. Pond water, evapd. to dryness, was dissolved in H_2SO_4 and shaken with xylenol and the nitroxylenol was transferred into NaOH with benzene, after which extinction was detd. Control expts. agreed within 1.5%.—*CA*

The Colorimetric Determination of Nitrates in Water. E. HLUCHAN & J. MAYER. Chem. Zvesti (Czech.), **10**:387 ('56). Colorimetric method for detn. of small amts. of nitrates in water by Na salicylate and trichloroacetic acid is described. Max. absorption of yellow-colored solns. is at 410 mμ. Direct dependence of color intensity on amt. of nitrates is up to 70 γ NO_3^- in 50 ml. Interfering effect of cations can be eliminated by filtration through ion exchanger. Of anions NO_3^- increases color intensity; it can be eliminated by addn. of small amt. of Na azide in ion exchanger before filtration. I^- and Br^- decrease yellow-color intensity in amts. over 25 γ.—*PHEA*

A Colorimetric Method for Determining Dissolved Oxygen. C. S. OULMAN & E. R. BAUMANN. Sewage and Ind. Wastes, **28**:1461 ('56). Spectrophotometric method for colorimetric detn. of I_2 released in Winkler method (*Standard Methods for the Examination of Water, Sewage, and Industrial Wastes*, **1955**, 10th Ed., Am. Public Health Assoc., New York) for dissolved O_2 is described. Construction and calibration of instrument are given. Effect of wave length (mμ) on percentage transmittance of light

(Continued on page 76 P&R)

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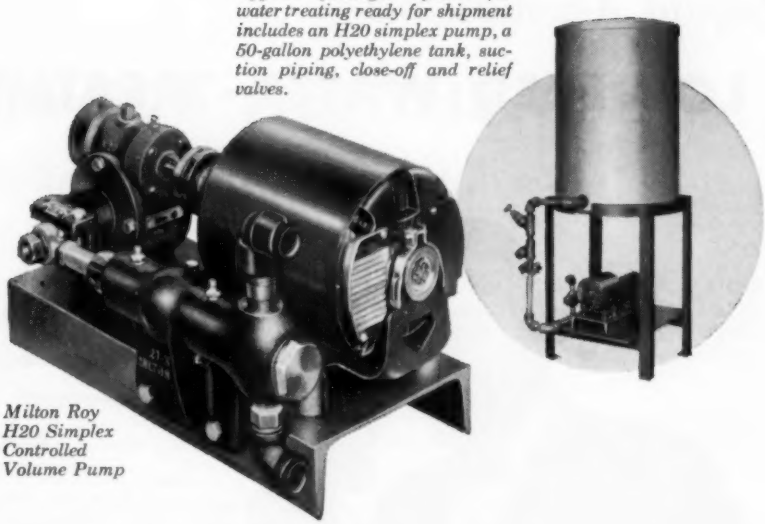

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(Continued from page 72 P&R)

through dissolved O_2 samples contg. Winkler reagents is illustrated in series of curves. Advantages of method include elimination of standard solns., reduction of analytical time, simplicity of method, and direct correlation with standard method.—*CA*

Applications of a Colorimetric Microanalytical Technique for Phosphorus to Waters to Which Polymetaphosphates Have Been Added. G. VAN BENEDEN. Bull. Centre Belge Etude et Document. Eaux (Liege), **35**:33 ('57). To unknown add sufficient concd. H_2SO_4 to obtain a concn. of 2% vol./vol. Reflux for 30 min. To 10-ml sample add 2 ml 5% $(NH_4)_2MoO_4$; stir, and wait 5 min. Add 1 ml 20% Na_2SO_3, followed by 1 ml 0.5% hydroquinone (1 drop concd. H_2SO_4 should be added to stock hydroquinone soln.); stir and wait 25 min. Measure absorption at 650 mμ. In range of 0.01–0.06 mg/ml P Beer-Lambert law is obeyed. All reagents should be kept in paraffin-lined vessels to prevent Si interference, which becomes significant at concns. above 2 mg/l. Fe does not interfere. Directions are given for avoiding Si interference and for applying anal. procedure specifically to complex polymetaphosphates, waters to which they have been added, and org. materials. In hexametaphosphate-treated waters Fe can be satisfactorily detd. by the dipyridyl method.—*CA*

The Volumetric Determination of Sulfates in Natural Waters. A. I. KAZ'MIN. Gidrokhim. Materialy (USSR), **24**:38 ('55). Method is based on pptn. of SO_4^{--} with excess of a $BaCl_2$ soln. of known concn., excess of which is pptd. with excess of 0.1 *N* Na_2CO_3 soln., then unreacted Na_2CO_3 soln. was detd. by titration with 0.1 *N* HCl.—*CA*

Use of Dithizone for the Colorimetric Determination of Zinc in a Potable Water. M. D. MANITA. Trudy Komissii Anal. Khim., Akad. Nauk S.S.S.R. (USSR), **7**: 194 ('56). To 1 ml of potable H_2O in porcelain dish, 0.1 ml of 10% HCl is added and evapd. on water bath; then 5 drops of H_2O added again and evapd. Dry residue is transferred to 10-ml calibrated test tube; 1 ml of 0.01 *N* NaOH is added, dild. to mark with H_2O, then 1 ml of dithizone (40 mg/100 ml) in alc. soln. is added and after 20 min measured with colorimeter. Most intense color is obtained at concn. of Zn between 0.0001 and 0.0015 mg/ml at pH 11. Interfering elements are Fe, Cu, and Ag. —*PHEA*

CORROSION

Polarographic Control of Water Pipe Corrosion. Z. NOWAK. Wasserwirtsch.-Wassertech. (Ger.), **5**:388 ('55). Methods to det. and control water pipe corrosion are presented with particular emphasis on polarographic approaches to problem. Procedures for detg. influence of ground and surface water on pipe corrosion are divided into a direct method: immediate handling of metal surface affected by water, and an indirect method: phys. and chem. qual. and variation in water, Fe, and CO_2 content, acidity, alky., elec. cond., pH, and absorption are considered. Polarograph is utilized to study production of drinking water from surface water, wherein coagulation and pptn. are employed in purification operations.—*CA*

Prevention of Caustic Corrision in Steam Boilers. L. STANISAVLIEVICI. Energetica, **4**:269 ('56). Under certain circumstances, alk. nature of boiler water can influence corrosion. This can be eliminated, by maintaining protective ratio of Na_2SO_4:Na_2CO_3, where Na_2SO_4 has inhibitor effect by applying alk. orthophosphates to maintain necessary alky. in boiler; and by maintaining protective ratio of $NaNO_3$:NaOH or KNO_3:NaOH or, for boilers of low pressure, tannin:NaOH.—*CA*

Intrinsic Protection of Water Mains. M. UNZ. Corrosion, **12**:526T ('56). Protection against corrosion is essential in water supply systems. Ext. corrosion can be reduced by use of cement coatings and separation of heterogeneous line sections and internal galvanic action is eliminated by sepn. or matching of materials. Problem can be solved completely only by use of electrically nonconducting pipes; while int. corrosion and blocking of pipes can be prevented by water treatment. Irrigation system was investigated, confirming that bare or bituminous-coated steel components are anodic to cement-coated lines; irrigation outlets during dry season are also usually anodic to trunk line. Protective value of cement coating is intrinsically increased due to chem. absorption process in anodic areas. Presence of

(Continued on page 78 P&R)

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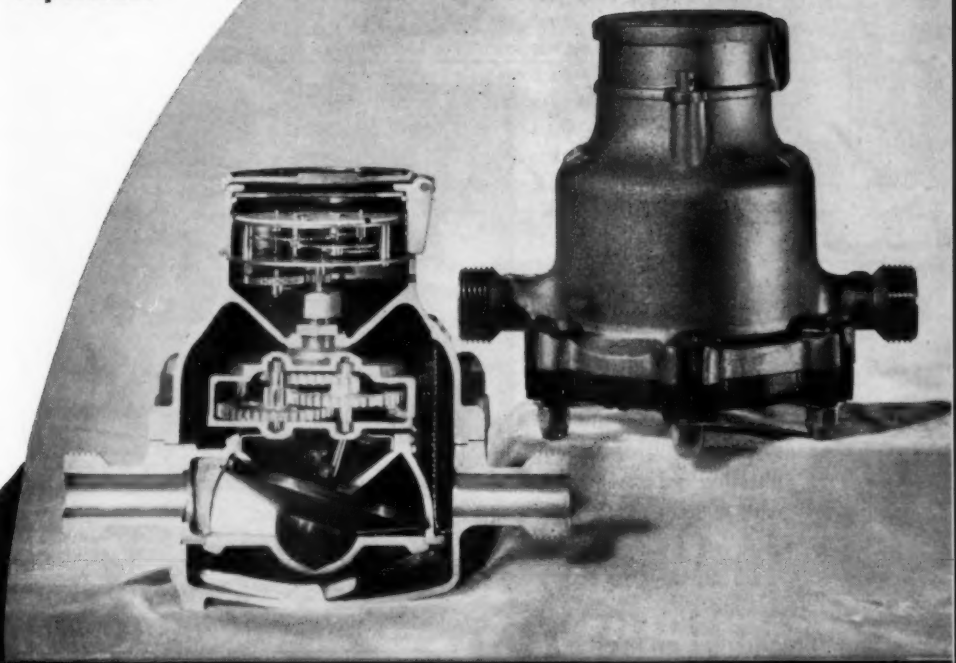

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(Continued from page 76 P&R)

adequate layer of pure cement over steel surface is essential for this protective effect. —*WPA*

Hypotheses on the Corrosion of Boiler Evaporator Tubes. E. C. Potter & R. L. Rees. Bul. Centre Belge Etude et Document. Eaux (Liège), **32**:73 ('56). Many existing hypotheses that explain corrosion in boiler tubes with boiler operating at high pressure are critically discussed. None explain formation of heavy magnetite deposits or corrosion embrittlement of adjacent metal. —*CA*

Cathodic Protection and Water Treatment Stop Corrosion. M. J. Olive. Oil Gas J., **54**:220 ('56). In water systems contg. large amts. of minerals and corrosion products, corrosion and scale accumulation in condenser channels, tube sheets, and floating heads often cannot be prevented by using one or more corrosion inhibitors in water. Mg anodes, when installed on channel covers of condenser, will give good corrosion protection in systems with treated water. Anode life can be prolonged by coating most of surface with neoprene.—*CA*

Corrosion in Condensate System can be Controlled. R. G. Dalbke. Power Engr., **60**:89 ('56). Corrosion in condensate systems is discussed as to causes and results. Importance of CO_2 is stressed. Methods of control include either destruction of corrosive gases at outset or formation of protective coatings in system. Use of amines for latter purpose is discussed.—*CA*

Corrosion Problems in Water Supply, with Special Reference to Phosphate and Silicate Protective Coatings. W. Christ. Wasserwirtsch.-Wassertech. (Ger.), **6**:68 ('56). Double phosphates of type of $FeCa_2(PO_4)_2$ and $Al_2CA_3(PO_4)_2$ form extremely insol. films, which, when deposited upon pipes, provide good protective coating against corrosion. Films can be deposited directly from water load by balancing mineral content by minor addns. of salts, acids,

(Continued on page 80 P&R)

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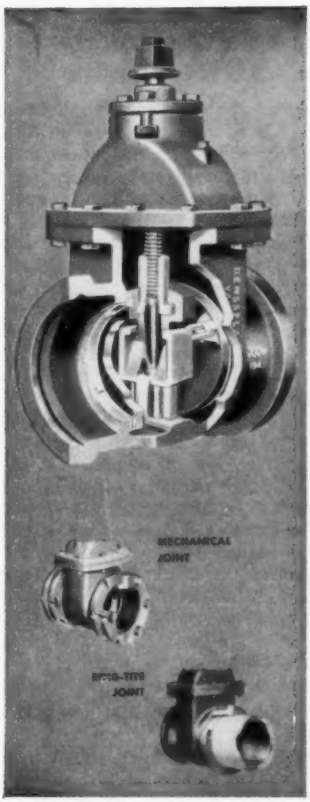

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LUDLOW RENSSELAER **VALVES & HYDRANTS**

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(*Continued from page 78 P&R*)

or bases. For acid water with high CO_2 content app. is described, charged with calcined $Ca_3(PO_4)_2$ and Na carbonate over a layer of silica gel. For waters contg. non-Fe minerals, silicic acid addns. or mixts. of phosphate and silicic acid are used.—*CA*

Studies in the Corrosion of Metals Occasioned by Aqueous Solutions of Some Surface-Active Agents. IV. Aluminium. H. Holness & R. D. Langstaff. J. Appl. Chem. (Lond.), **6**:115 ('56). Study was made of action of dil. aq. solns. of anionic, cationic and non-ionic wetting agents on Al, using distd. water and London tap water. Method of prepn. of solns. used and general exptl. procedure are described. Some of anionic surface-active agents covered metal with water-repellent film which gave protection. When attack occurred it took form of pitting, pits being covered with nodules of corrosion product. All cationic agents had some action, and most marked appeared to exert a solvent action. Non-ionic agents had little effect. Many of metal specimens immersed in tap water solns. acquired deposit of calcium carbonate crystals. Results, using certain named surface-active agents, are expressed graphically, and possible mechanism involved in their action on metal is discussed. —*WPA*

The Evaluation of Cooling Tower Corrosion Inhibitors. W. L. Denman & C. B. Friedman. Corrosion, **13**:179T ('57). Results are given of lab. expts. on control of corrosion in small commercial cooling tower in which pH value of recirculating water was rigidly controlled. It was found that, to maintain desired residual concn. of polyphosphate in water, it was necessary to apply about 4 times calcd. amt. With chromates, only normal calcd. amts. were usually required. Increase in temp. increased rate of corrosion, but temp. coefficient was not generally as high as chem. kinetics would indicate.—*WPA*

Corrosion by High-Purity Water. A Symposium. Corrosion, **13**:69T ('57). In symposium on high-purity water in industry, held at 11th Annual Conference of National Association of Corrosion Engineers in Mar., 1955, papers were presented on corrosion of metals by high-purity water, on methods of preventing such corrosion, and on uses of high-purity water in various industries.—*WPA*

A Corrosion Problem in Large Steam-generating Stations. T. J. Finnegan. Corrosion, **13**:405T ('57). Int. corrosion of boiler tubes frequently starts with pinhole leak which enlarges until it is large enough to cause tube to be torn apart. Heavy deposits of black oxide frequently are found in tube at or near point of failure. Possible explanations for presence of this oxide are: Fe removed from piping and equipt. in preboiler circuit may be carried back into boiler when O-free alk. environment favors its pptn. as black Fe_3O_4. Some factors may prevent formation of protective film which is needed to prevent bare metal from coming into contact with water. One method of combatting this type of corrosion involves maintenance of an optimum concn. of "free caustic" in boiler water. Another method is to clean boiler periodically with low-strength HCl. Many boiler operators have found it helpful to make the condensate alk. in order to protect preboiler equipment. Cyclohexylamine, morpholine, and NH_3 were used in this connection; although favorable results were reported in many cases, there is some lack of agreement as to effectiveness of such compds.—*CA*

LABORATORY METHODS

Spectrochemical Analysis of Water. R. Ko. U.S. Atomic Energy Comm., **HW-48770** ('57). Trace quant. of several metals can be detd. in water by evapn.-spectrographic method with In as the int. standard. Add 500 λ In soln. (10 ppm in 3 N HCl), 1 ml HCl, and 1 drop 1:100 HF to 50-ml sample water in 50-ml Erlenmeyer flask. Evap. to dryness on hot plate. Take up residue in 500 λ hot HCl. 1 drop of Apeizon (1% in petroleum ether) is used to treat flat graphite electrode. Mount 150 λ on pair of treated electrodes and dry under heat lamp. Prep. blank in similar manner. Expose on spectrograph and process plate. By use of following lines in A., indicated limits of anal. in ppm can be obtained: Zn 2502.0, 0.010; Mn 2605.7, 0.001; Fe 2737.3, 0.005; Mg 2790.8, 0.002; Pb 2833.1, 0.005; Cr 2843.3, 0.001; In 3039.4, internal standard;

(*Continued on page 82 P&R*)

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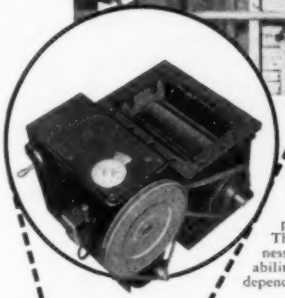

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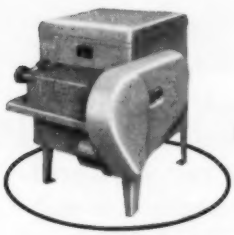

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(Continued from page 80 P&R)

Al 3092.0, 0.002; Ca 3179.3, 0.010; Cu 3274.0, 0.002; Ni 3380.6, 0.020; Co 3412.3, 0.005; Zr 3438.2, 0.001.—*CA*

A Conductivity Bridge for Measurement of the Salinity of Sea Water. K. E. SCHLEICHER & A. BRADSHAW. J. Cons. Intern. Explor. Mer, **22**:9 ('56). Description is given of a conductivity-bridge type of salinometer for use on ship, in which salinity of sample of seawater is detd. by comparing its cond. with that of sample of known salinity at same temp. General arrangement of instrument is shown in diagram and photographs. Results of tests made with salinometer on cruises in Sargasso and Caribbean seas proved practicability and sea-worthiness of instrument, and also pointed out need for certain improvements.—*WPA*

Progress in the Complexometric Determination of Water Hardness. W. NIELSCH. Glas-Email-Keramo-Tech. (Ger.), **7**:287 ('56). Titration with disodium ethylenediaminetetraacetate (EDTA) is reviewed as a method for measuring total hardness, as well as Ca and Mg in industrial water. Eriochrome Black T, or Eriochrome Blue Black, is used as indicator in total hardness detns. Ca hardness is detd. by using NaOH and murexide indicator. When carbonates are present, they are first decomposed with HCl, before making sample alk. for Ca titration. In phosphate-contg. water, EDTA is added in excess, after removing carbonates, and then back-titrated with CaO (1 g/1000 g H_2O). Interference of Fe and heavy metals is prevented by reaction with Na pyrrolidine carbamate and extraction of reaction product with $CHCl_3$. Al is sequestered with triethanolamine. The use of KCN, Na_2S, triethanolamine, and 2,3-dimercaptopropanol as sequestering agents for interfering metals is reviewed in detail.—*CA*

A Modified Palmitate Method for the Estimation of Total Hardness of Water. W. G. MACMILLAN & M. C. MITRA. J. Ind. Chem. Soc. (Ind.), **19**:182 ('56). Hardness of water can be detd. by titration with pal-

(Continued on page 84 P&R)

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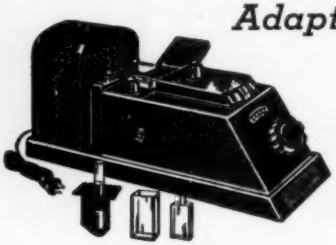

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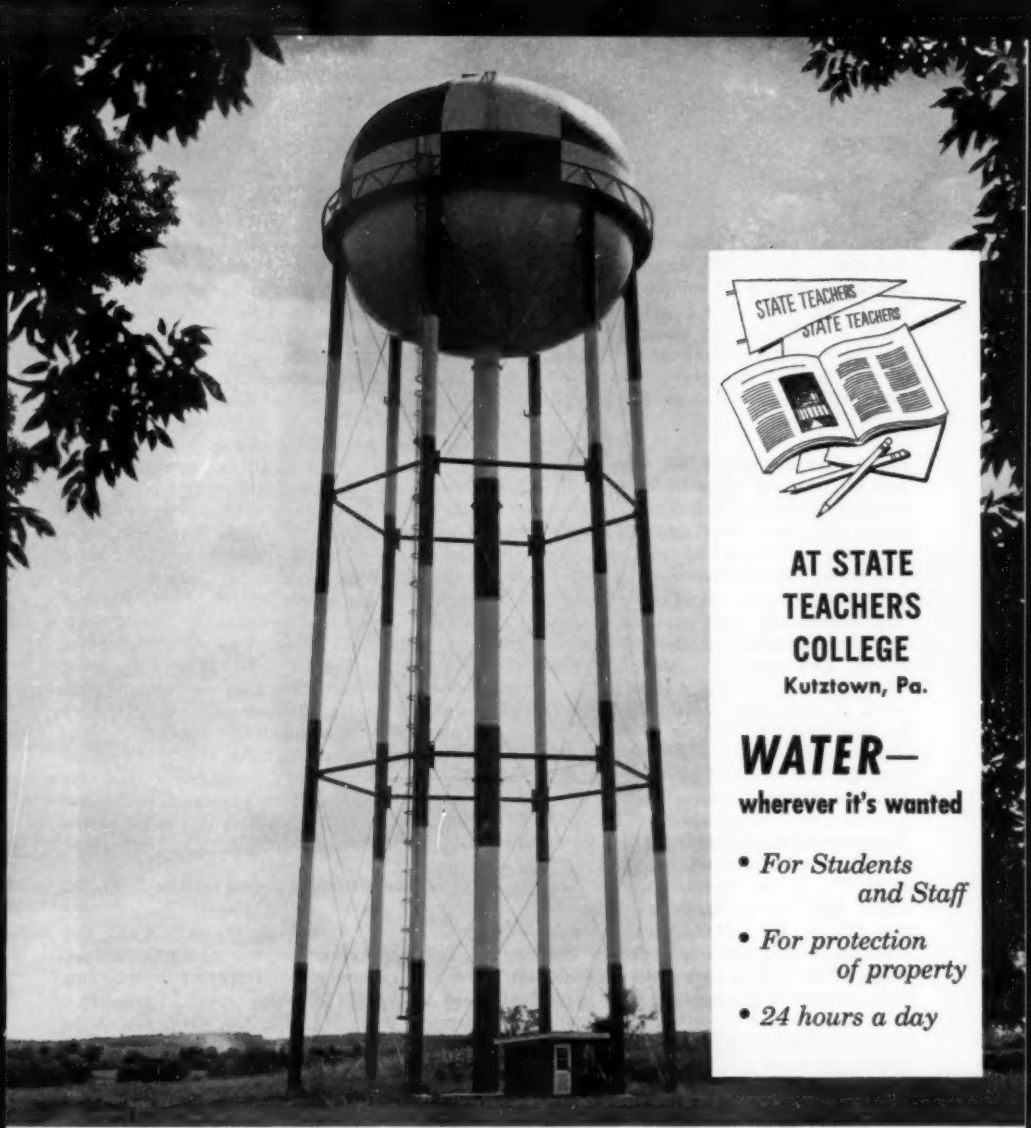

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(*Continued from page 82 P&R*)

mitate, by using Eriochrome Black T as indicator. Make 100 cc sample alk. by treating with 2–3 cc soln. contg. borax 40, NaOH 10, and Na_2S 5 g/l. Titrate with 0.1 N K palmitate, by using 1 cc of 0.5% Eriochrome Black T as indicator, until all of reddish color disappears. This method is rapid and accurate enough for use as good routine test.—*CA*

An Automatic Meter for the Determination of Residual Silica in Water. H. F. J. Scrase. Chemistry & Industry ('56), p. 919. Meter has been developed for continuous, automatic recording of residual silica in boiler feed water after ion-exchange treatment for removal of silica. App., shown diagrammatically, and procedure for silica detn. are described in detail; silica is estimated colorimetrically and absorption is transmitted electronically from vacuum photocell to recording meter. Time required for one complete detn. is 20 min. Results obtained on prototype instrument were as accurate and sensitive as those obtained on standard absorptiometer.—*WPA*

Determination of Hardness in Waters by the Vereenata Method. L. B. de Ruella & H. V. A. de Alderuccio. Revista de Obras Sanit. de la Nacion (Buenos Aires), No. 162, p. 451 (Mar.–Apr. '55). Water hardness in Argentina is generally detd. by soap method. Since soap gives only approximate content of Ca and Mg ions present in soln., use of more precise and rapid versenate method is suggested. Methods suggested are those of Diehl, Goetz, and Hach. Disodium salt of ethylenediaminetetraacetic acid (EDTA) in alk. soln. reacts with Ca^{++} and Mg^{++} forming compds. which ionize but little. End point in such reaction is detd. by using colored hydroxylates as indicators. Among these, best appears to be that commercially known as Eriochrome Black T, tribasic acid that functions as acid-base indicator, with 2 changes in color: wine red to blue. Ca forms colored compd. with indicator which is not sufficiently stable to use as end point. Mg is necessary for complete reaction. Presence of ions other than Ca and Mg, even in minute amts., caused difficulties in reading end point. Soln. of known concns. of Mg and Ca were made up and different quant. of Cu, Fe, and Mn also added. Cu at 0.2 or more mg/l interfered with color change. Addn. of sodium diethyldithiocarbamate to indicator soln. eliminated interference of Cu up to 5 mg/l. Iron interferes in low concns. if the indicator is added before the buffer soln.; if the buffer is added first, concns. up to 1 mg/l. Fe does not interfere, but with greater concns. the end point is not clear. Addition of hydroxylamine chlorohydrate to indicator soln. and resultant mixt. added to test sample after buffer soln. Fe ions will not interefere until concns. of 20 mg/l are reached. Mn in ionic state does not interefere, but its oxides give confusing end point. Addn. of hydroxylamine chlorohydrate to indicator soln. will reduce Mn present. Simultaneous presence of appreciable quants. of Ca^{++} and CO_3H^- ions causes great difficulties in reading end points or prevents clear end point altogether. Results were obtained by using solns. of known concns. of Ca^{++} and CO_3H^- ions. Delay in titration following addn. of buffer soln. to sample and in high concns. dil. of samples with distd. water was found successful if titrated immediately.. Reagents used are prepared as suggested by manufacturer, as well as following routine methods.—*PHEA*

Chromatography Applied to Water Analysis. H. Lecoq. Bul. Centre Belge Etude et Document. Eaux, **31**:16 ('56). Qual. and quant. applications for chromatographic anal. of waters are given. Specific instructions are given for following: NH_4, ferric iron, ferrous iron, Mg, Pb, Co, OCl, Cl_2, NO_2, NO_3, sulfur and CN. Techniques, app., advantages, and applications are discussed.—*PHEA*

The Limitations of Microchemical Volumetric Analysis. R. Czensny. Vom Wasser (Ger.), **22**:243 ('55). Author discusses various difficulties in increasing sensitivity of titration methods for microanalysis. He deals with difficulties of high dilns. of titration soln., design of microburets, and methods of reducing size of drop entering titration vessel. He suggests investigating effect of detergents in reducing surface tension and thus size of accumulated drop.—*WPA*

Method of Trilonometric Determination of Hardness. N. P. Tsyba, M. P. Beisova, & P. A. Kryukov. Gidrokhim. Materialy (USSR), **24**:44 ('55). Trilonometric

(*Continued on page 86 P&R*)

DELIVERING WATER CHEAPER

This 48,980-foot water supply line at Spartanburg, S. C., was installed in 50-foot steel pipe lengths. Ease in making up the Dresser joints was the factor in speeding up installation of the line, thereby causing a minimum of inconvenience to property owners.

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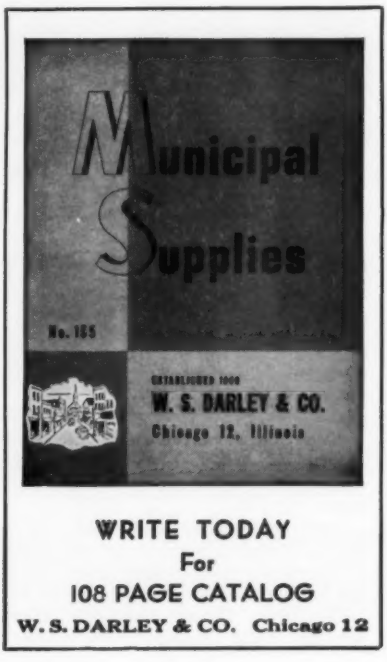
(Continued from page 84 P&R)

method for detg. hardness in water is simpler and more accurate and sensitive than other methods. Blue-Black Acid Chrome is best of 5 hardness indicators tabulated. In acid medium, it is red-orange, changing to light-blue at pH around 8. This light-blue, typical of alk. medium in absence of Mg ions, is best of colors for identifying end of titration. Second transition of color is at pH 11.5 to 12.0, when indicator becomes dark blue-violet. Sharpest change is at pH 10 to 11, so optimum range or hardness detn. is wider. In alk. medium in presence of Mg ions, it turns wine-red. But waters with high carbonate alky. need to be slightly acidified for the test. In titrating solns. with Ca ions only, a certain amt. of Mg salt soln. must be added. Differing proportions of Ca^{++} and Mg^{++} in solns. do not affect accuracy of present method. Slight deviations (−2.1% to +1.0%) in hardness of natural waters, measured by conventional anals. and by trilonometric method, are tabulated. Accuracy of trilonometric method is vitiated by presence of some ions, esp. iron, in excess of 1 mg/l (not 20 mg/l, as stated in literature). To remove org. iron compds. (and any Mn ions present), NH_4Cl was added; ammonia was added until methyl red turned orange; 3 to 4 drops of ammonia were added. Soln. was heated to 80°, 0.1 N $KMnO_4$ soln. was added until pink color remained stable for 15 min. 1–2 ml alc. was added to remove color, and soln. was kept 10 to 15 min at 80° until pptn. coagulated. It was filtered off and washed 4 to 5 times with hot water. To get needed pH in filtrate, usual buffer soln. did not suffice, so ammonia was added in presence of Blue-Black Acid Chrome to a wine-red color. Then titration with Trilon B proceeded.—*CA*

An Electrometric Method for the Determination of Small Quantities of Chlorides. P. M. DESCHAMPS. Bul. Soc. Chim. Fr., No. 1 ('56), p. 126. Low concns. of chlorides can be titrated in aq. or aq. acetone solns. by dead-stop technique, with silver or gold amalgam as one electrode and silver as

(Continued on page 88 P&R)



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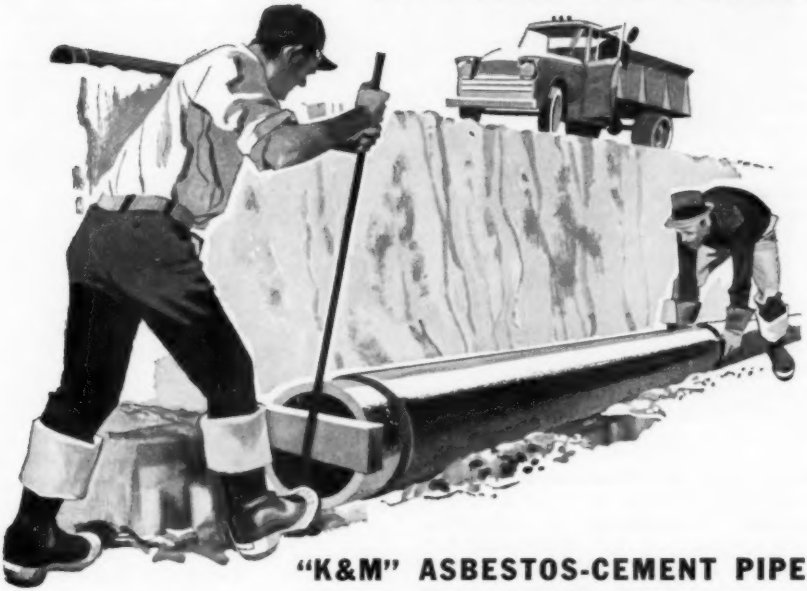

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(Continued from page 86 P&R)

the other. Small quant. of added sulfuric acid increases sensitivity. Solns. containing as little as 91 μg in 25 ml are satisfactorily titrated, but for such dil. solns. it is necessary to plot curve of current against vol. of added silver nitrate soln. and to det. end point graphically. Possibility of extending method to detn. of bromide and iodide is discussed.—*WPA*

Application of Trilonometry for Determining Activity of Natural Waters. A. A. ZENIN. Gidrokhim. Materialy (USSR), **24**: 49 ('55). Method of detg. water hardness by titrating with Trilon B, tried on aq. solns. of $Ca(HCO_3)_2$, was as accurate as more tedious, less economical present method which measures alky. by direct and back titration. Piped city water, partly satd. with gaseous carbonic acid, was used to measure active carbonic acid trilonometrically and by detg. Ca carbonate as at present. There was no significant difference.—*CA*

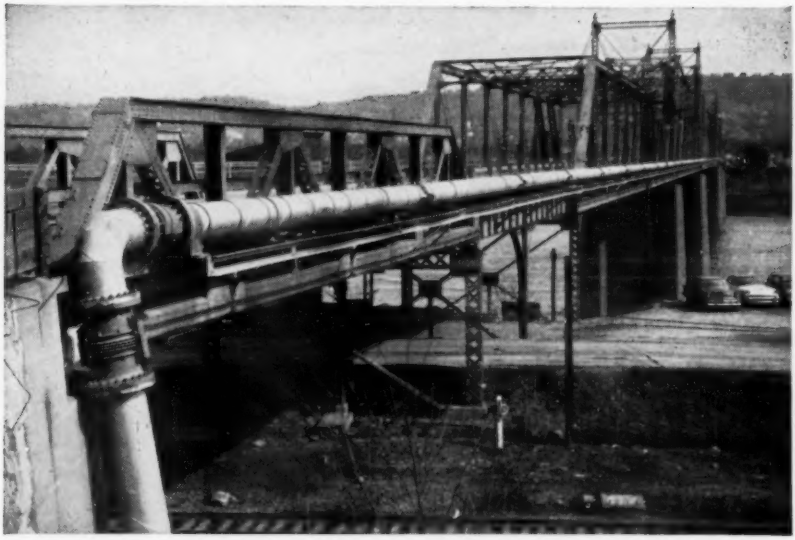
Methodology of Determining Unstable Compounds Directly at Water Source in Regional Hydrogeologic Investigations. I. Y. SOKOLOV & Z. I. KUZNETSOVA. Gidrokhim. Materialy (USSR), **24**:15 ('55). Chem. changes in water during trip to lab. cause hydrochem. anal. errors. Standard colorimetric detns. are made at source with some special reagents. For pH, reagent is bromomethyl blue 0.0134, methyl red 0.0034, caustic potash 0.0018 and powd. sugar 20 g crushed in an agate mortar. Reagent for Fe^{++} is K ferricyanide 1.00 and powd. sugar 9 g crushed in an agate mortar. For nitrite ions reagent contains α-naphthylamine 0.01, sulfanilic acid 0.10, tartaric acid 0.89, and powd. sugar 9.00 g. For Fe^{+++}, 0.1 g K thiocyanate is used per anal.; it is placed in tablet between 2 thin layers of KCl to reduce its hygroscopic effect. For H_2S, reagent is prepd. by pulverizing *p*-aminodimethylaniline 0.125 with 9.875 g K_2SO_4 sulfate; to 6.5 g ferric-ammonium alum dissolved in 100–150 ml distd. water in 250-ml flask, 85 ml concd. H_2SO_4 (sp gr 1.84) is added, cooled, filled with water, and mixed; 0.417 g KIO_3 is pulverized with 9.582 g KI; 1 0.5-g tablet combines with 10 mg H_2S.—*CA*

The Chromatographic Determination of Organic Substances in Natural Waters. J. HOLLUTA & J. TALSKY. Vom Wasser (Ger.), **22**:212 ('55). Authors discuss the necessity for developing new methods of anal. to detect and identify substances causing taste and odor in bank-filtered water and in surface water used direct for supply. As quants. are small, either concn. or isolation of substances is required. Concn. can be accomplished by passing water through a sand filter, equipped for back washing, and then through filter of active carbon. Active carbon is dried without heating and extracted with org. solvents. It was found that various solvents extracted mixts. of different composition from carbon and that not all material taken from water could be extracted from carbon. Direct extraction of water with diethyl ether is possible and is best carried out in countercurrent at pH values first of 4.5 and then of 8. Extracts can, by methods which are described, be sepd. into basic, amphoteric, neutral, phenolic, and acid fractions. Paper-chromatographic method for identification of constituents of these fractions is described and illustrated by examples. This method permits more efficient identification of nature of poln. than those previously used. Experiments on Rhine water and bank-filtered Rhine water showed that neutral fraction was source of taste and odor and that, in addn. to town sewage, waste waters from chem. industry and poln. from navigation were responsible. Character of poln. was altered by filtration through river bed and banks. Methods described can be used for identifying poln. of surface, ground, and bank-filtered water, for examn. of sewage, and for detg. nature and origin of substances causing taste and odor. As the method of extraction of pold. water with solvents, separation of extract into fractions, and examn. of fractions by paper chromatography is likely to have increasing importance in examn. and treatment of water, authors are making further investigations with view to improving and simplifying process. Investigations are also required on products of metabolism and decompn. of bacteria and fungi.—*WPA*

SOFTENING AND IRON REMOVAL

Dealkalization and Its Application to Water Treatment. E. RIMBERG. Natl. Engr., **58**:24 ('55). Na-zeolite-anion dealkalization system can be used to reduce

(Continued on page 90 P&R)



Armco Pipe, 24 inches in diameter, .312-inch wall thickness, brings water across the Ohio River on the Ambridge, Pennsylvania, Bridge.

Armco Steel Pipe provides high strength —minimum weight for bridge crossing

The city of Ambridge, Pennsylvania, needed a pipe line across the Ohio River to provide an increased water supply. The pipe was to cross the river on the Ambridge Bridge. This required a pipe strong enough to withstand water pressures and to span bridge brackets without substantially increasing the load on the bridge.

Armco Welded Steel Pipe provided the necessary strength without excess weight. The pipe was hoisted from a barge on the river onto pre-placed bridge brackets, and joined with mechanical couplings.

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(*Continued from page 88 P&R*)

return-line corrosion with no special corrosion-resistant equipt. and no repumping.—*PHEA*

Demineralization of Water by Freezing. L. KERVRAN. L'Eau, **43**:13 ('56). In areas such as North Africa, where water is at premium, salt-laden sea water could be reclaimed. Techniques are described where, with ionic exchange or solar distn., sea water can be demineralized. Cost is not considered too great.—*PHEA*

The Elgastat Portable De-Ionizer. Lab. Pract. (Lond.), **5**:45 ('56). App. for demineralization of water, Elgastat contains mixt. of strong anion and cation-exchange resins. Unit is small and compact and requires no permanent connection to water mains or power. Raw water is placed in polythene storage tank, with capac. of 2.25 l, until it is required. If head of feed water in storage tank is maintained, max. capac. of app. is 15.5 l per hr. When resin is exhausted it is replaced with new resin cartridge. Treated water, with specific resistance of more than 1 megohm/cm, contains no detectable amts. of heavy metals, chloride, sulfate, or free ammonia, only traces of albuminoid ammonia, and little oxidizable matter, and has pH of 6.6–7.0. Data on approximate output and comparative costs for several towns in Great Britain are shown in table.—*PHEA*

Zeolites, Their History and Applicability to Water-Treatment Problems. E. NORDELL. Natl. Engr., **60**:22 ('56). Description with photographs of zeolite water softeners and their regeneration. Data on heat transfer of boiler scale and soly. of various scales are tabulated, also properties of principal types of Na cation exchangers.—*CA*

Experimental Investigation of Pressure Installations Used in Removing Iron from Water. K. A. MAMONTOV. Vodosnabzhenie i Sanit. Tekh. (USSR), **3**:21 ('56). Description and diagram of exptl. pressure-filter installation. Anthracite was used as filter medium for contact filter, quartz for other filter. Efficiency of either filter depends upon speed of filtration, size of granules of either filter medium, and height of filter column. Finer granules, slower speed and higher column greater is amt. of Fe removed during certain time period. Tested under identical conditions, contact filter is less efficient.—*CA*

Pure Water by Ion Exchange. Chem. Tr. J. (Br.), **140**:864 ('57). Portable app. for demineralization of water, Mark V Portable "Deminrolit," is described. It consists of 2 columns of ion-exchange material, first containing the cation-exchange resin Zeo-Karb and second anion-exchange resin De-Acidite. App. has output of 6 gph.—*WPA*

The Hardness Triangle. F. SCHWILLE. Gas- u. Wasserfach, **98**:280 ('57). Ternary diagram for hardness, with coordinates temporary hardness, permanent hardness, and total hardness, is of value in studying variation of hardness with location of wells, springs, etc., and also in studying changes in hardness at given location.—*CA*

The Practical Application of Electrodialysis to the Desalting of Brackish Water. O. B. VOLCKMAN. Brit. Chem. Eng., **2**:146 ('57). New low-cost membranes recently devised by South African Council for Scientific and Industrial Research make electrodialytic desalting of brackish water economically feasible, owing to their longer life and greatly reduced power consumption as compared with conventional type milled ion-exchange resins previously used as membranes.—*CA*

The Improvement and Control of a Hot Lime-Soda Water Softener. K. L. FLOYD & A. W. FLOYD. Eng. and Boiler House Rev. (Br.), **72**:152 ('57). Feedwater supply may change in hardness from 250 to 400 ppm within few hrs, so changes had to be made to sampling point of 1st-stage sedimentation tank to secure more rapid recognition of changes. Spraying of both water and chem. in this plant was improved. NaOH was used to replace soda ash and part of lime, since lime soda-ash process produced heavy deposits on dosing equipt. Calcn. of chem. requirements is discussed. Anal. results show marked improvement in water qual.—*CA*

Influence of Ultrasonic Vibrations on the Formation of Calcium Carbonate in Hard Waters. R. CYPRES. Bul. Centre Belge Etude et Document. Eaux (Liege), **35**:52 ('57). Pptn. of $CaCO_3$ from city water of Charleroi, Belg., has been initiated by sub-

(*Continued on page 92 P&R*)

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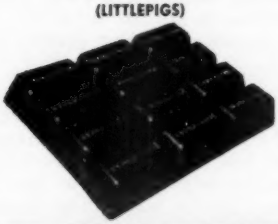

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HYDRO-TITE

HYDRAULIC DEVELOPMENT CORPORATION

(Continued from page 90 P&R)

jecting water to ultrasonic vibrations. Ppt. is in form of aragonite crystals, size of which decreases with power per unit area of impressed vibration. More degassing occurs with treated water that has been heated than with water merely heated.—*CA*

HYDRAULICS

Patterns of Motion in Open-Channel Bends. T. M. P. CHACINSKI. J. Inst. Wat. Engrs. (Br.), **10**:420 ('56). Investigation was made into pattern of spiral motion in flow of water in meandering open channels, rectangular in section with 45° bends connected direct or by short, straight sections. Studies also made to det. influence of secondary flow at entry on spiral flow, and of bed load movement. Some observed patterns and bed load movements shown in diagrams and photographs. Application to rivers and control of erosion and deposition is discussed.—*WPA*

Design of Stable Canals and Channels in Erodible Material. P. W. TERRELL & W. M. BORLAND. Proc. Am. Soc. Civil Engrs., Vol. **82**, HY1, No. 880 ('56). In paper on design of irrigation canals and channels an outline is given of background and development of current practice used by US Bureau of Reclamation in detn. of canal section, and factors to be integrated into design of canals are listed and discussed. In dealing with design of channels to transport water with sediment load, consideration is given to importance of factors causing changes in stream regimen. Methods by which design of stable channel may be computed are described, and example is presented. Basic data necessary for channel design are listed.—*WPA*

Design of Venturi Flumes in Circular Conduits. E. A. WELLS & H. B. GOTAAS. Proc. Am. Soc. Civil Engrs., Vol. **82**, SA2, No. 928 ('56). Lab. expts. were conducted to provide data on accuracy and design criteria of Venturi flumes of Palmer and Bowlus type, and to examine influence of various flume dimensions such as throat length, base height, and entrance transition on accuracy of flume for recording flow measurement in circular pipes. Results are discussed and conclusions are drawn regarding design and accuracy of flume.—*WPA*

Research Needs in Sediment Hydraulics. E. J. CARLSON & C. R. MILLER. Proc. Am. Soc. Civil Engrs., Vol. **82**, HY2, No. 953 ('56). Some of problems in field of sediment hydraulics encountered by US Bureau of Reclamation engineers in planning, design and maintenance of irrigation projects are discussed. These problems include sampling techniques, methods of computing sediment load, design of stable channels in earth materials, sediment deposition in storage reservoirs, and exclusion of sediment from irrigation and power plant supplies. Need for research is indicated, and some methods for soln. of problems are advanced.—*WPA*

Hydrograph Analysis by the Method of Least Squares. W. M. SNYDER. Proc. Am. Soc. Civil Engrs., Vol. **81**, No. 793 ('55). Technique is described by which complex storm hydrographs can be analyzed by method of least squares to give sets of coefficients defining time and distr. of runoff. By repetitive procedure an estimate of volume of runoff can be detd. simultaneously with distr. coefficients. Technique was applied to storms in 2 watersheds of Tennessee Valley Authority, and shape of storm hydrograph is discussed in relation to stability and nature of vegetation covering ground surface.—*WPA*

Gelatinous Coating Produces Friction Loss in Piping System. J. R. BAYLIS. Pure Water, Vol. **7** ('55). In period Aug. '45 to May '47, inside surfaces of pipes of South Water District water distr. system, Chicago, became coated with gelatinous slime, which reduced carrying capac. by 10–30%. Water treatment at that time comprised coagulation and sedimentation, but did not include filtration. During this period, activated silica was added in small amts. at various times, and this may have aided formation of slime. Lime was also added, but amt. used was not enough to form coating. Coating was mainly composed of silicon dioxide and aluminium hydroxide, and formed ridges at right angles to direction of flow, as shown by photographs. pH value was raised to prevent corrosion of cast-iron water mains, which also occurred to some extent. No slime coating has been observed since filters were put into operation in 1947. —*WPA*

(Continued on page 94 P&R)

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In laboratory tests, a Builders Butterfly Valve was cycled *over a quarter million times*, and tested bubble-tight at 25 psi. Valve operation was easy at all times. There was no leakage at the gland and wear on shaft and bearing was negligible.

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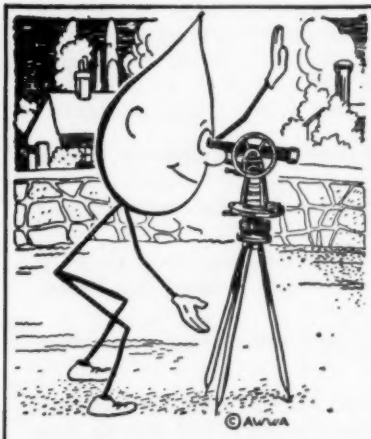
(*Continued from page 92 P&R*)

Flow of Fluids in Conduits and Open Channels. E. S. CRUMP. Proc. Inst. Civil Engrs. (London), **5**:522 ('56). Empirical and exponential formulae devised by engineers to express rate of flow of water in open channels and pipes are reviewed, and are compared with approach of physicists to problem. More scientific approach led to use of Reynolds number, laws for rough and smooth boundaries, and culminated in development of Colebrook-White transition formula of universal application. Validity of Colebrook-White formula in practice has been confirmed by results of data collected from many sources.—*WPA*

Hydraulics of Wells. D. F. PETERSON. Proc. Am. Soc. Civil Engrs., No. 708 ('55). General development of theoretical well hydraulics, including formulae for equilibrium and nonequilibrium conditions, and hydraulic effects of wells and well components such as screens, and gravel packs, are reviewed. Application of theoretical developments to practical engineering problems is discussed.—*WPA*

A More Simplified Venturi Tube. J. C. STEVENS. Proc. Am. Soc. Civil Engrs., No. 678 ('55). Description is given of simplified Venturi tube made up of 2 AWWA cast-iron reducers, and having pipe pressures balanced by water under air pressure, instead of by mercury. Characteristics of tube are described and compared with those of Herschel Venturi tube, and flow formula for simplified tube is given.—*WPA*

La Mesure des Niveaux par Dispositif Electrostatique. (The Measurement of Levels by Electronic Equipment.) L'Eau, **43**:133 ('56). Electronic app. for measurement of levels in open or closed res. is described and illustrated. This type of equipment may be more useful than such mechanical equipment as manometers and floats, or such electrical equipment as immersed electrodes.—*PHEA*



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(*Continued from page 56 P&R*)

Soil moisture and density measurement by means of the "d/M-Gauge" shown in the photo below is said to be simple, speedy, and accurate. According to the manufacturer, Nuclear-Chicago Corp., 229 W. Erie St., Chicago 10, Ill., a single, nontechnical operator can obtain accurate determinations in one-tenth the time required by conventional methods. The instrument is based on the principle that radioactive particles are "scattered" in varying degrees by masses of different moisture content or density. Measurements are obtained by inserting a probe into the material being tested and reading the scatter count on a scaler. A calibration chart is then used to relate the reading to moisture content or density. In addition to soil studies, the device can be employed for such purposes as investigating ground water movement and checking the content of concrete mixes.

John A. Sargent has resigned as president and director of Diamond Alkali Co., Cleveland, Ohio. His presidential duties and responsibilities have been assigned to Raymond F. Evans, board chairman and chief executive officer for the past 3 years. A. H. Ingley, senior vice-president, has been named to the newly created post of executive vice-president. Mr. Sargent joined the company in 1946 as treasurer and became president in 1954, succeeding Mr. Evans.

(*Continued on page 98 P&R*)

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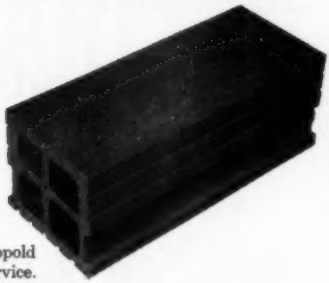
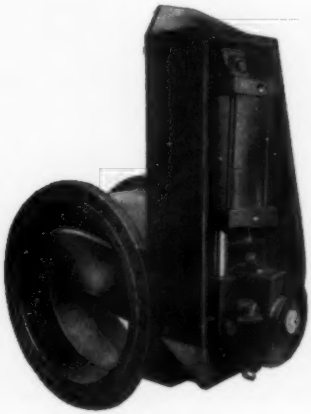
FILTER BOTTOMS



Designed to successfully meet all underdrain requirements

Made of de-aired fire clay—vitrified and salt glazed, the Leopold Filter Bottom is unequalled for dependable, economical service. The individual blocks resist corrosion, are not subject to tuberculation, and will last indefinitely. Too, they require only small sized gravel, do not need special supporting concrete members, and the Leopold design insures uniform wash distribution.



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Assure positive drop-tight shut-off easily, efficiently, economically.

In this design, the seat is of resilient Neoprene rubber or pure gum rubber, vulcanized around a steel ring insert, and held in place by a keeper ring. The steel ring, which is "continuous" to eliminate abnormal wearing, increases the firmness of the seat and assures longer service life.

Whether operated manually or by automatic controls, Leopold Butterfly Valves always provide a positive shut-off that's bubble-tight. Made in sizes 6" to 96".

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The new edition of *Standard Methods for the Examination of Water, Sewage, and Industrial Wastes* is now available. The 522-page book—over 200 pages larger than its predecessor—includes new material on methods, theory, significance of results, and expected accuracy and sensitivity.

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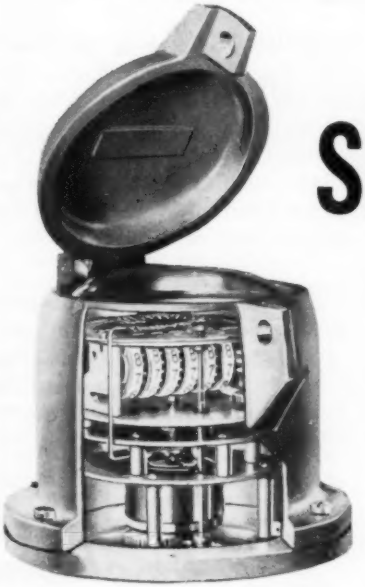
(*Continued from page 96 P&R*)

A pipe pusher attachment now available for the Henry Hydraulic Backhoe drives ¾–3-in. pipe through sand, clay, or rocky soil. Using the Henry Backhoe, one man can dig the trench, replace the bucket with the "Ram-A-Rod" pusher, and complete the job. According to the manufacturer, Henry Mfg. Co., 1700 N. Clay

St., Topeka, Kan., the machine is capable of reversing direction quickly, so that it can pull pipe out if a major obstruction is encountered. Equipped with tempered tool steel driving jaws, the pusher is said to require a minimum of maintenance and to be easy to transport (it is approximately 53 in. in length and 14 in. wide).

(*Continued on page 100 P&R*)



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(Continued from page 98 P&R)

Russell L. Sylvester has been promoted to engineering executive assistant at Republic Flow Meters Co. of Chicago, a recently acquired subsidiary of Rockwell Mfg. Co. He was formerly chief engineer of Rockwell's Central Valve Research & Development Dept.

Robert L. Rice has been named general sales manager for Fischer & Porter Co., Hatboro, Pa. He is succeeded as manager of the firm's Water & Waste Div. by James Haskett.

Henry L. Shuldener, president of Water Service Labs., Inc., has been elected chairman of the New York Chamber of Commerce committee on health and welfare.

C. S. Pinkerton has retired as division manager, industrial-control sales, Cutler-Hammer, Inc., Milwaukee, Wis., after 43 years with the company.

Max G. Walker has been appointed sales manager of the Pittsburgh office of Hammond Iron Works. He was formerly southeastern sales manager for the firm.

Irving V. A. Huie, president of the New York City Board of Water Supply, died Aug. 30, 1957, at the age of 68. Born in Brooklyn, N.Y., he was graduated from New York University in 1911. In 1918 he was named a New York State deputy highway commissioner. After a brief period in this position, he entered private engineering practice and, in 1931, joined the firm of Madigan & Hyland, where he worked on the planning and construction of numerous New York City projects. In 1937 he was appointed the first chief engineer of the New York City Dept. of Public Works, later becoming commissioner. While in this position, he also served as WPA administrator for the city from 1941 till 1943. In 1945 he was made a member of the Board of Water Supply and was its president at the time of his death.

Federal engineering positions in various fields to be filled by examination are described in a new brochure available from the US Civil Service Commission, Bureau of Departmental Operations, Washington 25, D.C.

Employment Information

Classified ads will be accepted only for "Positions Available" or "Position Wanted." Rate: $1.50 per line (minimum $5.00), payable before publication. Deadline for ad copy: first of month prior to month of publication desired. To place ad, obtain "Classified Ad Authorization Form" from: Classified Ad Dept., Journal American Water Works Assn., 2 Park Ave., New York 16, N.Y.

Positions Available

SANITARY ENGINEERING—Positions available with the New York State Department of Health. Duties include all phases of Sanitary Engineering. B.S. degree in sanitary, public health, civil or chemical engineering required. Salary: $5,246–$6,150, Junior grade; $6,140–$7,490, Assistant grade; $7,500–$9,090, Senior grade (N.Y. State P.E. license required for Senior grade). Address inquiries to New York State Department of Health, Office of Personnel Administration, 84 Holland Avenue, Albany 8, New York.

Sanitary Engineers II and III; salary ranges $460–$575, $575–725 respectively; two to four years' experience in public health or sanitary engineering; excellent retirement and fringe benefits; liberal leave policy and travel allowances. Write Personnel Officer, Florida State Board of Health, P.O. Box 210, Jacksonville 1, Florida.

Planning a municipal water-softening installation?

If you are, an important decision you'll have to make is how much space to set aside for salt storage. This article—number 8 in a series prepared by International Salt Company—gives important information on salt-storage principles.

How to determine space needs for rock salt storage

To help you determine quickly how much space you need to store salt at your installation, International has developed a system for computing storage-space needs. With this system, you can also select the shape of salt pile best suited to your individual plant layout.

There are 2 basic principles of salt storage. First, one cubic foot of rock salt (loosely poured and medium packed) contains an average of 72 lbs. of salt. And second, every conical pile formed by pouring rock salt from a fixed overhead point assumes the same shape—namely, a perfect cone, with an angle of repose of 32° from the horizontal. In other words, for every 12-inch horizontal run, there is a 7½-inch rise. With these basic principles, then, it is possible to determine just how large a pile will be formed by any tonnage of rock salt.

Tables give complete area and volume data. For the convenience of salt-using companies, International has prepared a comprehensive set of tables with all the storage-space data for amounts of salt ranging from three to 23,000 tons. With these tables, for example, you can quickly find exactly the amount of space needed to store 3,000 tons of rock salt. (The answer is a single, conical pile 100 ft. in diameter at the base, and 31 ft. high.)

In many treatment plants, however, it is not possible to store salt in one large, conical pile. Here again, the data in the tables permit you to select the height or length of windrow pile best suited to your needs. The same 3,000 tons of salt can be poured from a portable conveyor belt into a pile 65 ft. wide, 20 ft. high, and 100 ft. along the crest . . . or into a pile 75 ft. wide, 23 ft. high, and 55 ft. along the crest.

Other uses for the tables include computing the amount of salt present in any given storage pile . . . and finding the surface area of an outdoor pile, so you'll know just what size tarpaulin you'll need if you want to cover the pile. These tables are included in a comprehensive booklet, "Brine for Today's Industry," which will be sent to you at your request.

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Through skilled and experienced "Salt Specialists," we can help you get greater efficiency and economy from the salt or brine you use for regeneration. We produce both Sterling Evaporated and Sterling Rock Salt in all types and sizes. So we can recommend the type and size of salt most perfectly suited to your needs.

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Anticipate Surge

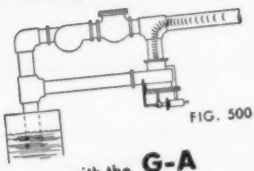

FIG. 500-A

with the G-A
ANTI-SURGE VALVE
Bulletin W-16

Relieve Surge

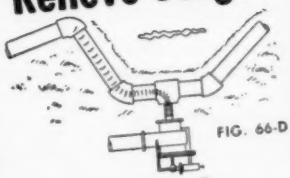

FIG. 66-D

with the G-A
SURGE RELIEF VALVE
Bulletin W-2

Prevent Surge

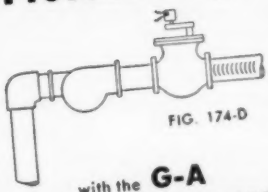

FIG. 174-D

with the G-A
ELECTRIC CHECK VALVE
Bulletin W-10

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Safety materials for public utilities are listed in a 14-page catalog, "National Safety Council Publications for the Public Utilities Section," which may be obtained by writing to the council's headquarters, 425 N. Michigan Ave., Chicago 11, Ill.

Cushioned valves are described in a folder, Bulletin G-5, offered by Golden Anderson Valve Speciality Co., 1232 Ridge Ave., Pittsburgh 33, Pa.

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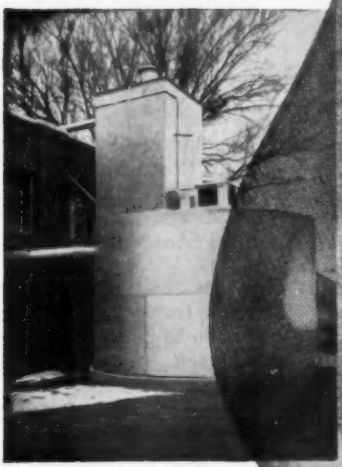
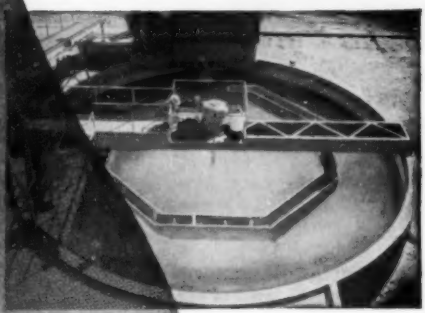
A rotary air compressor is the subject of an 8-page bulletin, No. P-106B, which can be obtained by writing to the Sales Promotion Dept., Le Roi Div., Westinghouse Air Brake Co., Milwaukee 1, Wis.

(*Continued on page 104 P&R*)

Why General Filter?

There are many reasons why municipalities and industries have installed General Filter water treating plants.





INSTALLATION SUPERVISION . . . General Filter "job-engineers" each installation to the consulting engineer's specification . . . supervises the installation and trains the personnel who will work with the equipment.

OPERATIONAL DEPENDABILITY . . . for twenty years General Filter has concentrated all of its efforts toward "better water treatment". Their efforts have produced water treating plants and equipment that are completely dependable.

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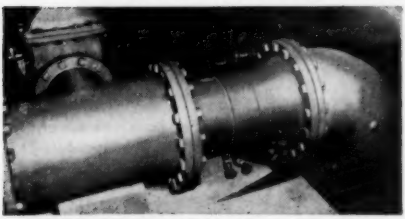
LOW INSTALLATION COST—Gentile Flow Tubes can be installed with no straight run upstream or downstream, except where near valves or regulators.



Actual installation of a 16" Flow Tube for REVERSE FLOW. Note fittings (elbow and tee) are bolted directly to flanges of Flow Tube.

Gentile Flow Tubes can be furnished with or without suitable secondary indicating, recording, or totalizing instruments.

GENTILE Flow Tubes are manufactured exclusively by Foster Engineering Company

Write for further information or specific recommendations.

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AUTOMATIC VALVES • CONTROL VALVES
SAFETY VALVES • FLOW TUBES

Service Lines

(*Continued from page 102 P&R*)

Pertinent facts about chlorine, safety precautions, and recommended practices for handling it in gas or liquid form are all discussed in Technical Bul. WWC3B4, available from Fischer & Porter Co., 230 Jacksonville Rd., Hatboro, Pa.

The Tarrant hydraulic slide rule, incorporating the Hazen-Williams and Manning formulas, is described in a 4-page brochure issued by Paterson Engineering Co., Windsor House, Kingsway, London, W.C. 2, England.

Relays, solenoids, plant control units, and switches are among the products featured in the 170-page, spiral-bound electromagnetic-control catalog, No. 57-S, available from Automatic Switch Co., Florham Park, N.J.

Threadless pipe fittings, made of malleable iron, for joining steel or plastic pipe, have been developed by Telsco Fittings Div., 5422 Redfield St., Dallas, Tex. The product is described in Catalog E, available from the manufacturer.

pH electrodes for laboratory and portable pH meters are featured in a 8-page bulletin, 86-5, issued by Scientific Instruments Div., Beckman Instruments, Inc., 2500 Fullerton Rd., Fullerton, Calif.

Rotameter selection is facilitated by a movable disc and chart incorporated in Bul. 110, published by Brooks Rotameter Co., Lansdale, Pa.

Revolving bins, adjustable shelves, and other types of storage equipment are featured in the new catalog published by Precision Equipment Co., 4411B Ravenswood Ave., Chicago 10, Ill.

Testing apparatus for soil characteristics, along with other laboratory equipment, is included in the 1957 edition of the Soiltest Catalog, available from Soiltest, Inc., 4711 W. North Ave., Chicago 39, Ill.

(*Continued on page 106 P&R*)

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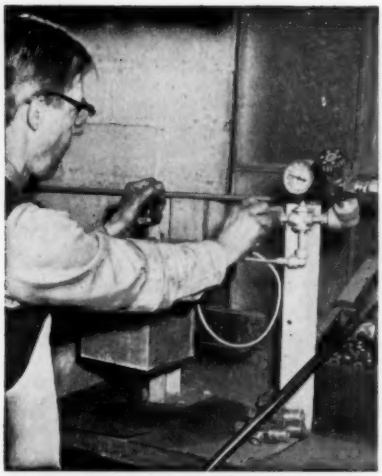

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Tele: Elgin 4-5503, 6-3321

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Tele: Franklin 6-7790, 6-1922

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Service Lines

(Continued from page 104 P&R)

Polyethylene plastic pipe and fittings are described in the 8-page Bul. CE-57, issued by Supplex Co., Div. of American Hard Rubber Co., 93 Worth St., New York 13, N.Y.

Gate and needle valves, made of forged steel, are the subject of a 12-page folder, Bul. DH80, released by R-P&C Valve Div., American Chain & Cable Co., Inc., Reading, Pa.

Concrete gunning equipment, its design, specifications, and operating capacities, are discussed at length in a 16-page catalog, containing many on-the-job photographs, which may be obtained from Air Placement Equipment Co., 1009 W. 24th St., Kansas City 8, Mo.

Plastic pipe fittings and valves are listed, described, and priced in a 22-page catalog issued by Sloane Mfg. Co., 12270 Montague St., Pacoima, Calif.

Remote-reading gages which are designed for high or low mounting and can be inclined upward or downward to approximately 30 deg, are the subject of a data sheet (Supplement 291) obtainable from Jerguson Gage & Valve Co., 80 Adams St., Burlington, Mass.

A line-operated pH meter, Model 85, designed to sell inexpensively, is described in Circular 195, issued by Photovolt Corp., 95 Madison Ave., New York 16, N.Y.

Pressure filters, designed for centralized control, are described in a 4-page brochure, FB-100, available on request from Industrial Filtration Div., US Hoffman Machinery Corp., 103—4th Ave., New York 3, N.Y.

Thank You, Mr. Butts
for this most interesting letter

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March 20, 1957

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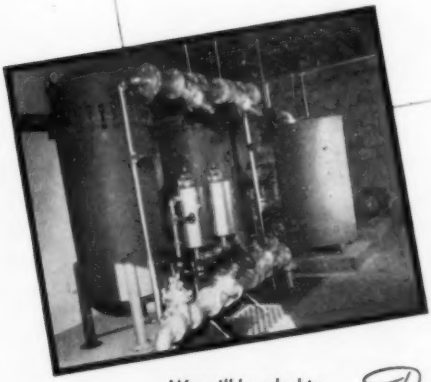
Very truly yours,

Herbert Butts

Herbert Butts, Supt.
Village of Sherburne Water Dept.



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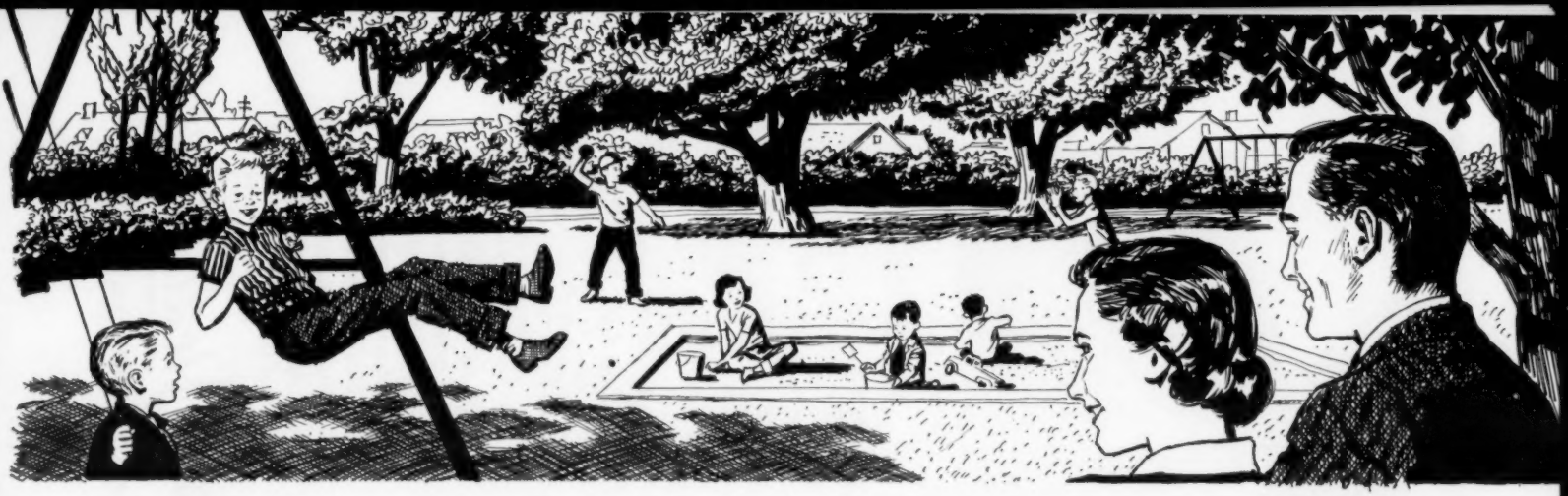

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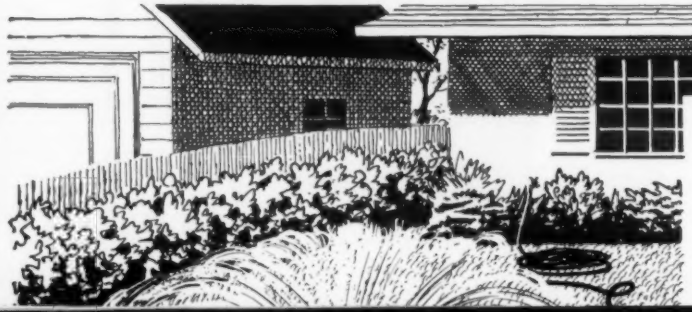
but what about their most precious possession...water?



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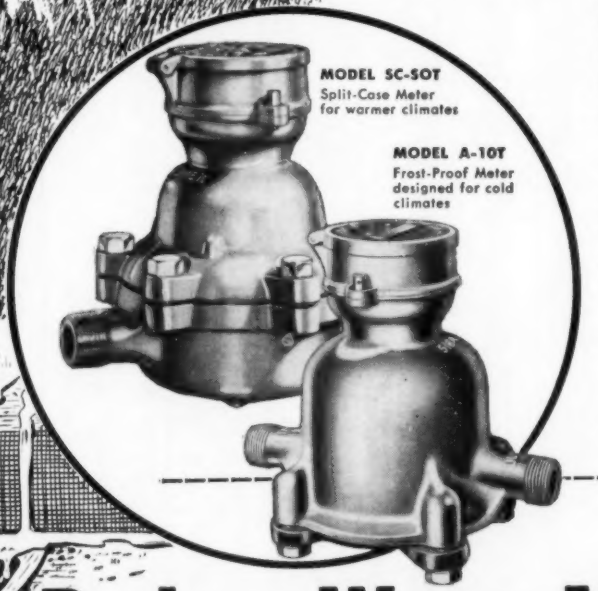

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Albert, A. William; *see* Vermont Water Conservation Bd.

Ball, Frank K., Acting Director, Waterworks, Newport, Ky. (Jul. '57) *MRPD*

Baumann, Kenneth Louis, San. Engr., State Dept. of Public Health, 301 W. Birch St., Champaign, Ill. (Jul. '57) *P*

Baumgartner, Elmer E., Supt. of Water, Water Dept., Box 403, Pandora, Ohio (Jul. '57) *MRPD*

Beard, Kennan H., Jr., Maintenance Foreman, Del Este Water Co., Box 561, Modesto, Calif. (Jul. '57) *MD*

Belz, William M., Jr., Water Treatment Oper., Rogers City Power Co., Rogers City, Mich. (Jul '57) *MP*

Bender, John W., Owner, Flecha Caida Water Co., Box 6412, Tucson, Ariz. (Jul. '57) *MRPD*

Benedict, Nathaniel K., Civ. Engr., Water Distr. Div., Dept. of Water & Sewers, 404 City Hall, 121 N. LaSalle St., Chicago 2, Ill. (Jul. '57) *M*

Berry, Garmon H., Field Engr., Biltmore Meter Repair Co., 5 Angle St., Biltmore, Asheville, N.C. (Jul. '57) *D*

Bissing, Norman Norbert, Supt. of Water Production, Hays, Kan. (Oct. '57) *RP*

Blan, Jim, Sales Repr., M. P. Schneller & Assocs. Inc., 1144 Dearborn, Aurora, Ill. (Jul. '57) *R*

Bonne, Han Iense, Student, Univ. of Wisconsin, Madison, Wis. (Jr. M. Jul. '57) *RPD*

Boulton, Glenn E., Mgr., The St. Joseph Water Co., 825 Francis St., St. Joseph, Mo. (Jul. '57) *M*

Brockville Public Utilities Com., 25 Front Ave., Brockville, Ont. (Corp. M. Jul. '57)

Bundy, Walter Alden, Dist. San. Engr., State Dept. of Health, 601 Hotel Jamestown Bldg., Jamestown, N.Y. (Jul. '57) *MRP*

Burke, George L., Cons. Engr., George L. Burke & Assocs., 816 Farmington Ave., West Hartford, Conn. (Jul. '57) *MRPD*

Bushby, Merritt; *see* City of Waverly (Iowa)

Campbell, John Rutherford, Pres., Rutherford Campbell Engrs., Inc., 701 Dun Bldg., Buffalo 2, N.Y. (Jul. '57) *MRPD*

Crompton, Francis Melvin, SA San. Engr., US Public Health Service, R. A. Taft San. Eng. Center, 4676 Columbia Pkwy., Cincinnati 26, Ohio (Jul. '57) *RP*

Deffley, Arthur H.; *see* South Coast County (Calif.) Water Dist.

Dierker, Gerard J., Exec. Vice-Pres., Jamaica Water Supply Co., 161–20 89th Ave., Jamaica, N.Y. (Jul. '57)

Embil, Juan; *see* Instituto Nacional de Hidrologia & Climatologia Medicas (Cuba)

Fairlamb, Richard H., Water Plant Foreman, 5001st Installations Sq., APO 731, Seattle, Wash. (Jul. '57) *MP*

Falcon, G. W., Marine Contractor, Falcon Marine Co., 1506 Elmwood, Evanston, Ill. (Jul. '57) *R*

Fuller, Frederic D., Chief of Lab. Bureau, State Water Conservation Bd., State Office Bldg., Montpelier, Vt. (Jul. '57) *RP*

Gates, Samuel J., Engr., 611 N. Broadway, Milwaukee 2, Wis. (Jul. '57) *RD*

Green, W. T., Jr., City Mgr., Box 911, Thomasville, N.C. (Jul. '57) *D*

Greenfield, Sydney D., Analyst, Edward C. Trax Lab., 2265 Greenock-Buena Vista Rd., McKeesport, Pa. (Jul. '57) *P*

Gregory, Carl W., Water Plant Supt., 311 E. Main, Osborne, Kan. (Oct. '57) *P*

Hanes, Earl N., Supt. of Utilities, Light & Water Dept., Ashland, Kan. (Jul. '57) *M*

Heninger, David C., Asst. Chief Engr., Calif. Water Service Co., 374 W. Santa Clara, San Jose, Calif. (Jul. '57)

Hernandez, Alberto, Chief, Tech. Sec., Public Housing Admin., Box 424, Rio Piedras, Puerto Rico (Jul. '57)

Hernandez, John W., Assoc. Engr., State Dept. of Public Health, Box 711, Santa Fe, N.M. (Jul. '57) *P*

Hetrick, G. Dale, Jr., Dist. Mgr., Fischer & Porter Co., 317 N. Gay, Knoxville, Tenn. (Jul. '57) *P*

Hewson, George, Water Engr., Box 1353, Bulawayo, Southern Rhodesia (Jul. '57) *MRPD*

Hicks, Robert B., Owner, Culligan Soft Water Service, 440 Southern Blvd., West Palm Beach, Fla. (Jul. '57) *RP*

Hopper, Harvey, Owner, Harvey Hopper Plumbing Co., 20 N. 9th, Fort Smith, Ark. (Jul. '57) *MPD*

Instituto Nacional de Hidrologia & Climatologia Medicas, Juan Embil, Head of the Dept. of Physics-Chemistry, Infanta & Zaldo, Habana, Cuba (Corp. M. Jul. '57) *R*

Jackson, Donald E., Mgr., Branford Div., New Haven Water Co., 100 Crown St., New Haven, Conn. (Jul. '57) *MD*

Ketcham, Alan H., Supt. of Supply, Stamford Water Co., 103 Summer St., Stamford, Conn. (Jul. '57) *RP*

Kirby, A. J., Editor, Public Works in Canada, 1706 W. 1st Ave., Vancouver, B.C. (Jul. '57)

Kristoff, Joseph Michael, Installation Engr., Installations Eng. Office, Stewart Air Force Base, Smyrna, Tenn. (Jul. '57) *MRPD*

(*Continued on page 112 P&R*)

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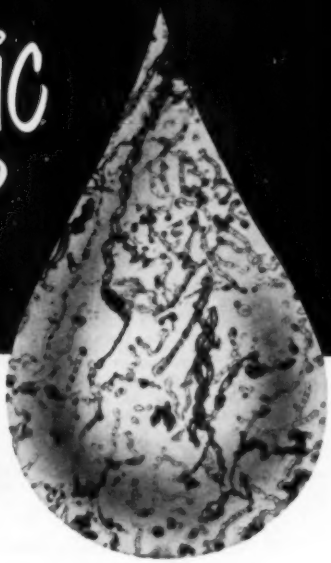

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(*Continued from page 110 P&R*)

Lanterman, W. G., Cons. Engr., 209 E. Washington, Ann Arbor, Mich. (Jul. '57)

Leach, Lawrence, Water & Sewage Plant Supt., Palmdale Water & Gas Co., 718 N.W. 1st St., Fort Lauderdale, Fla. (Jul. '57) *MRPD*

LeMaster, Edward R., Supt., Ponte Vedra Corp., Ponte Vedra Beach, Fla. (Jul. '57) *D*

Luckett, William J. L., Civ. Engr.-Design Engr., Michael Baker Jr., Inc., Station D., Jackson, Miss. (Jul. '57) *PD*

March, Henry A., Secy.-Treas., Public Service Com., Bridgewater, N.S. (Jul. '57) *M*

Markus, Albert, Water Supt., C.C.C. Water Works Dist. No. 1, Box 402, Brentwood, Calif. (Jul. '57)

Maross, Maynard; *see* Village of Steger (Ill.)

Martell, Grant A., 2nd Vice-Pres., New York Life Insurance Co., 51 Madison Ave., New York 10, N.Y. (Jul. '57) *MRPD*

Martin, James Clare, Professional Engr., Erickson Chem. Co., 333 N. Michigan, Chicago, Ill. (Jul. '57) *RPD*

McClary, Robert B., Co-Partner, Hydro Co., 3321 Century Blvd., Lynwood, Calif. (Jul. '57)

McCullough, Charles J., Const. Supt., E. L. William Inc., Whippany, N.J. (Jul. '57) *MD*

McDonald, James Charles, Chemist, State Bd. of Health, Old Capital Bldg., Jackson, Miss. (Jul. '57) *P*

McEwen, Robert S., Asst. San. Engr., State Dept. of Health, 101 N. High St., Columbus 15, Ohio (Jul. '57) *PD*

McGuinness, David Inglis, Chief Engr., Vivian Diesels & Munitions Ltd., 1660 Station St., Vancouver 4, B.C. (Jul. '57) *D*

McJohnston, Robert Edwin, Civ. Eng. Asst., Dept. of Water & Power, 222 S. Hill St., Los Angeles, Calif. (Jul. '57) *RD*

Mendenhall, Howard, Rend Lake Conservance Dist., 610 Wood Bldg., Benton, Ill. (Jul. '57) *R*

Meredith, Granville N., Supt., Munic. Water Works, Alta, Iowa (Jul. '57) *MRD*

Miller, Gerald J., City Engr., 155 S. Seward St., Juneau, Alaska (Jul. '57) *MRPD*

Moon, Clinton D., Jr., Mgr., New Jersey Water Service Co., 3 Paterson Ave., Little Falls, N.J. (Jul. '57) *MR*

Mosher, Harry D., Asst. Engr., Mosher Assocs., 14050 W. McNichols Rd., Detroit 35, Mich. (Jul. '57) *RPD*

Mosher, William C., Assoc., Mosher Assocs., 14050 W. McNichols Rd., Detroit 35, Mich. (Jul. '57) *RPD*

Nicolai, A. Lewis, Cons. Engr., U. S. Rubber Co., 1230 Ave. of Americas, New York, N.Y. (Jul. '57)

O'Malley, Edward F., Village Engr., 53 S. La Grange Rd., La Grange, Ill. (Jul. '57)

Parker, Lawrence A., Supt., Water & Sewerage Dept., Box 1517, Williamson, W.Va. (Jul. '57) *MP*

Perrin, P. H., Tech. Agent, Societe des Fonderies de Pont-a-Mousson, Nancy, France (Jul. '57) *D*

Powers, O. K., Supt. of Distr., 494 Kroft St., Galion, Ohio (Jul. '57) *MD*

Reimer, Frederic P., Cons. Civ. Engr., 217 Main St., Rotterdam Junction, N.Y. (Jul. '57) *RD*

Right, Norman D., Owner, Culligan Water Conditioning, Box 1379, DeLand, Fla. (Jul. '57) *P*

Robinson, Parker M., Jr., Engr., Operations, California Water Service Co., Box 1150, San Jose, Calif. (Jul. '57)

Rulison, John G., Geological Survey Div., Dept. of Conservation, 436 Stevens T. Mason Bldg., Lansing 26, Mich. (Jul. '57) *R*

Sarich, Anthony N., Southwest Regional Mgr., DeLaval Steam Turbine C., 1237 Texas National Bank Bldg., Houston, Tex. (Jul. '57) *MD*

Sarles, Frank Benton, Cons. Civ. Engr., 425 S. E St., Santa Rosa, Calif. (Jul. '57) *MRPD*

(*Continued on page 114 P&R*)

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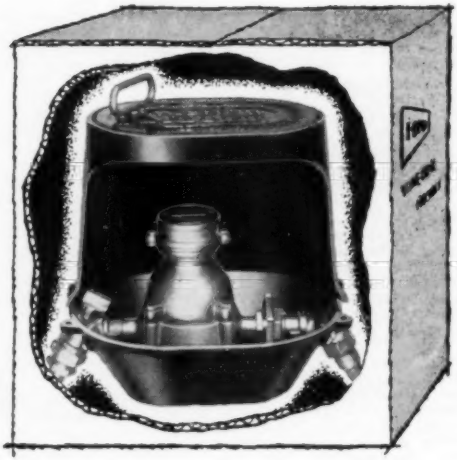

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(Continued from page 112 P&R)

Schuham, Milton, Structural Engr., Bureau of Eng., 320 N. Clark St., Chicago 10, Ill. (Jul. '57)

Schumann, Edward, Engr., Remsco, 75 West St., New York 6, N.Y. (Jul. '57) *PD*

Sherman, W. S., Jr.; *see* Sherman Machine & Iron Works

Sherman Machine & Iron Works, W. S. Sherman Jr., Vice-Pres., 26 E. Main St., Oklahoma City, Okla. (Assoc. M. Jul. '57)

South Coast County Water Dist., Arthur K. Deffley, Mgr., 31652 2nd Ave., South Laguna, Calif. (Corp. M. Jul. '57) *MD*

Steger, Village of, Maynard Maross, Supt. of Public Works, Steger, Ill. (Munic. Sv. Sub. Jul. '57) *MD*

Taylor, Ross., Engr.-Assoc., Hudgins, Thompson, Vall & Assocs., 1411 Classen Blvd., Oklahoma City, Okla. (Jul. '57) *R*

Thomas, Joseph R., Assoc., McGivern & Assoc., 3703 Pershing Ave., Cleveland 34, Ohio (Jul. '57) *PD*

Todd, Tom, Sales Repr., M. P. Schneller & Assocs., Inc., 1144 Dearborn Ave., Aurora, Ill. (Jul. '57)

Vedeskas, Stephen Paul, Asst. Engr., New Haven Water Co., 100 Crown St., New Haven, Conn. (Jul. '57) *RD*

Vermont Water Conservation Bd., A. William Albert, San Engr., State Office Bldg., Montpelier, Vt. (Corp. M. Jul. '57) *MRP*

Walker, Keith E., Sales Mgr., National Iron Div., Canada Iron Foundries Ltd., 169 Eastern Ave., Toronto, Ont. (Jul. '57)

Walker, Kenneth H., Assoc. Editor, Water Works Engineering, 305 E. 45th St., New York 17, N.Y. (Jul. '57) *MRPD*

Wallace, Ray, Mgr., Newport Hgts. Irrigation Dist., 116 E. 18th St., Costa Mesa, Calif. (Jul. '57) *M*

Wallace, Sterling, Water & Sewer Dept., Munic. Water System, Marvell, Ark. (Jul. '57)

Wardynski, Donald F., Sales Eng., Rockwell Mfg. Co., 525 Market St., San Francisco, Calif. (Jul. '57) *D*

Waverly, City of, Merritt Bushby, City Engr., Waverly, Iowa (Munic. Sv. Sub. Jul. '57)

Whiddon, Edwin L., Sales Engr., Rockwell Mfg. Co., 8933 Mt. Olympus, El Paso, Tex. (Jul. '57)

Williams, Delthon D., Mgr., Ridgecrest County Water Dist., 446 Ridgecrest Blvd., Ridgecrest, Calif. (Jul. '57) *MRPD*

Wise, Carlton Terrence, Head San. Eng. Dept., J. E. Sirrine Co., Greenville, S.C. (Jul. '57) *RP*

Withrow, Mitchell T., Chief Draftsman, Bradley, Patterson & Burgener, 607 Garden City Dr., Monroeville, Pa. (Jul. '57) *RP*

Wolf, Herbert C., Civ. Engr., Russell & Axon, 11324 Larimore Rd., St. Louis 15, Mo. (Jul. '57) *PD*

Womack, Kimzey, Sales, Viking Supply Corp., 5005 Greenville Ave., Dallas, Tex. (Jul. '57) *M*

Worley, James D., Field Engr., Automatic Control Co., 6346 W. McNichols Rd., Detroit 21, Mich. (Jul. '57) *D*

Wyskiel, Frank Alexander, Student of San. Eng., Lincoln Hall, Cornell Univ., Ithaca, N.Y. (Jr. M. Jul. '57) *PD*

Yarman, Maynard L., Chief Oper., Water Plant, 136 N. Gamble St., Shelby, Ohio (Jul. '57) *MRP*

Zahner, Andrew Arnold, Sr. Engr., Burns & McDonnell Eng. Co., Box 7088, Kansas City, Mo. (Jul. '57) *RPD*

Zelse, Carl Henry, Asst. City Engr., Box 317, Costa Mesa, Calif. (Jul. '57) *MD*

Zimmerman, Albert F., Lab. Director, Quality Control Lab., Pine Road, Fox Chase, Philadelphia, Pa. (Jul. '57) *RPD*

Zimmerman, Leslie L., Supt. of Utilities, Bd. of Trustees of Public Affairs, Covington, Ohio (Jul. '57) *M*

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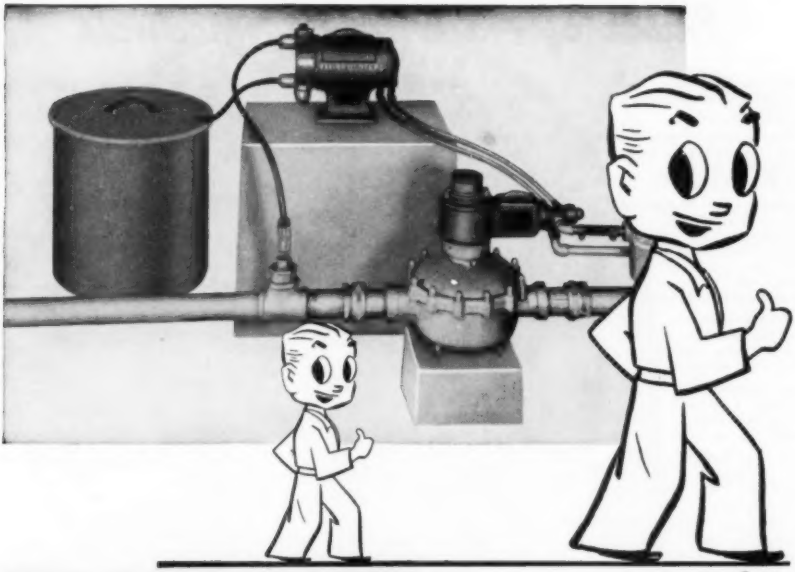

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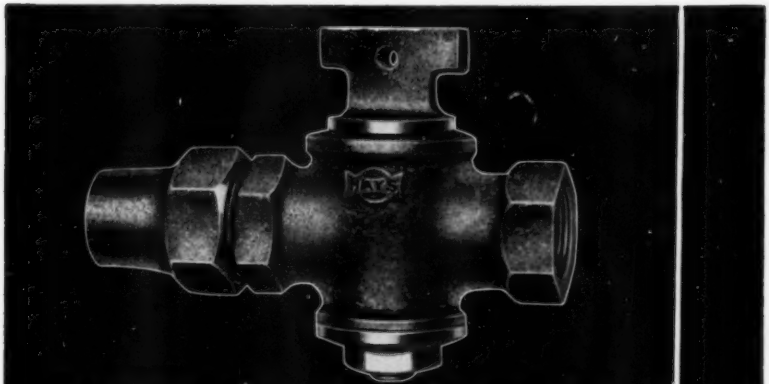

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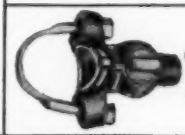

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Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Wallace & Tiernan Inc.

Turbines, Steam:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Turbines, Water:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.
R. D. Wood Co.

Valve-Inserting Machines:
Mueller Co.
A. P. Smith Mfg. Co.

Valves, Altitude:
Golden-Anderson Valve Specialty Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.
S. Morgan Smith Co.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Chapman Valve Mfg. Co.
James B. Clow & Sons
DeZurik Corp.
M. Greenberg's Sons
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.

Valves, Float:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
DeZurik Corp.
Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
F. B. Leopold Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Large Diameter:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Muller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Regulating:
DeZurik Corp.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co.
S. Morgan Smith Co.

Valves, Swing Check:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Venturi Tubes:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Infilco Inc.
Simplex Valve & Meter Co.

Waterproofing:
Barrett Div.
Inertol Co., Inc.
Koppers Co., Inc.

Water Softening Plants: see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Wallace & Tiernan Inc.

Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Cochrane Corp.
Dorr-Oliver Inc.
Etablissements Degremont
General Filter Co.
Graver Water Conditioning Co.
Hammond Iron Works
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.

Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite: see Ion Exchange Materials

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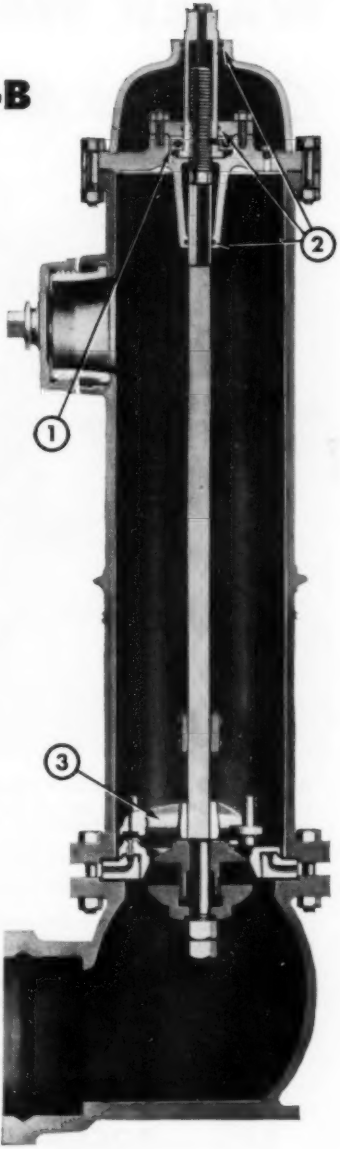
THE new Darling B-50-B is proving in city after city that it is today's truly outstanding hydrant—the easiest and least expensive to maintain . . . and the most dependable in meeting year-around conditions as they really *are!* Of the various features that contribute to such performance, here are three of major significance . . .

1. BALL BEARING DESIGN. It takes less than half the usual force to open and close this hydrant! Operation is easy, smooth, fast and *sure,* regardless of weather extremes.

2. "O" RING SEALS. This is a packless, *dry-top* hydrant! No stuffing box . . . no packing gland adjustment or maintenance . . . no bothersome lubrication or replacement of packing. Operating threads and bearings *stay* lubricated . . . and not a drop of water ever reaches them. No *opportunity* for trouble!

3. POSITIVE DRAINAGE, WITH AUTOMATIC FLUSHING. This effective, multi-port drainage feature makes freeze-ups virtually impossible. Drain valves are always open when the main valve is closed. During first several turns in opening and last several turns in closing, drain ports remain open temporarily, flushing ports under full line pressure.

With these and other superior design features, Darling B-50-B Hydrants offer exceptional surety in both performance and economy. It will pay to make them *your* choice. They are available in types and sizes for every normal and unusual requirement. Write for Bulletin 5710.



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WATER WASTE

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. . . and a much closer accuracy check provided!

A BIG RED HAND is furnished as standard construction on all Rockwell meter registers. Like the split second hand of a stop watch it sweeps the entire outer circumference of the dial. The slightest movement can be seen.

The big red hand is a tremendous aid when checking or demonstrating leaks in your customers' homes. And with this large, slow moving, center mounted test hand, you can get a much closer reading on the accuracy of new or repaired meters.

By any comparison—accuracy, durability, repair ease or convenience—Rockwell meters measure up to the highest standards. Ask our representative to demonstrate, or write today for latest bulletin.

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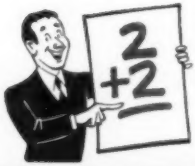
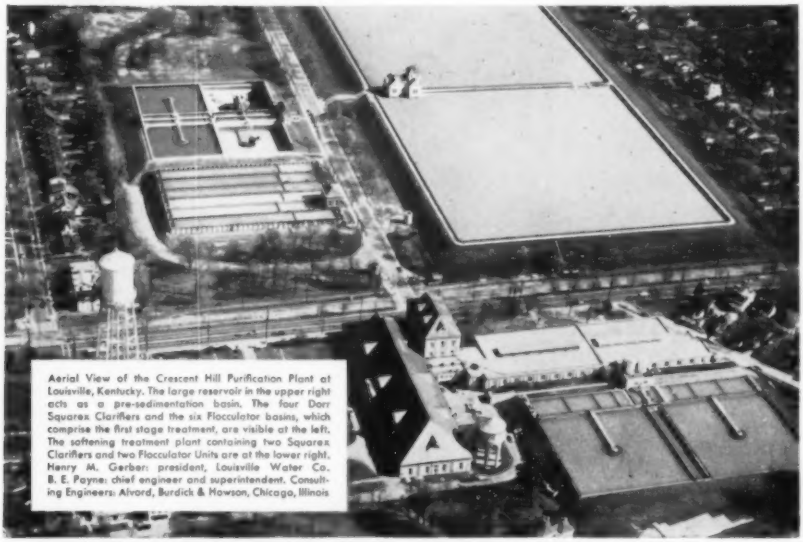
A Size and Type For Every Kind of Service



The solution to this problem is always the same . . . but

Water Treatment Problems are different

No two water treatment problems are exactly alike. The right solution to each can only be arrived at after a careful study of the local conditions. Variables such as raw water composition, rate of flow and results required automatically rule out the cure-all approach. The installation shown below is a good example of how equipment should be selected to fit the job . . . and not vice versa.



Aerial View of the Crescent Hill Purification Plant at Louisville, Kentucky. The large reservoir in the upper right acts as a pre-sedimentation basin. The four Dorr Squarex Clarifiers and the six Flocculator basins, which comprise the first stage treatment, are visible at the left. The softening treatment plant containing two Squarex Clarifiers and two Flocculator Units are at the lower right. Henry M. Gerber: president, Louisville Water Co. B. E. Payne: chief engineer and superintendent. Consulting Engineers: Alvord, Burdick & Howson, Chicago, Illinois

Louisville, Kentucky

Adds More Dorr Squarex Clarifiers for Increased Capacity

One hundred years ago the Louisville Water Company began construction of their water plant facilities with the erection of their first pumping station. In the early thirties six Dorrco Flocculator Units were installed for coagulation with a design capacity of 60 MGD. In 1945 two type SZ Dorr Squarex Clarifiers, each 200′ square, and two Flocculator Units for basins 176′ long, were installed inaugurating Louisville's softening treatment plant.

By 1954 rapid population increases necessitated a proportionate increase in water supply requirements, and four Dorr Squarex Clarifiers, each 150′ square, were installed in the first stage increasing the design capacity to 160 MGD.

Two additional Dorr Squarex Clarifiers, each 200′ square, and two type P Flocculator Units, for basins 179′ long and 50′ wide, have been ordered, which will provide softening for 160 MGD.

If you would like more information on the complete line of Dorr-Oliver Water Treatment Equipment, write Dorr-Oliver Incorporated, Stamford, Conn., for a copy of Bulletin No. 9141.

Every day over 8½ billion gallons of water are treated by Dorr-Oliver equipment

Squarex and Flocculator trademarks reg. U. S. Pat. Off.

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Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

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The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%

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